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THE TIME-CRITICAL TARGETING MODEL

by

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Contents

Page

Illustrations

Page

Preface

Early in my career I began thinking about the subject of time-critical targeting. As an electronic warfare officer on the RC-135V/W Rivet Joint, I saw firsthand my community's move from strategic reconnaissance towards a more interactive role in supporting theater operations at the tactical level. Operation DESERT STORM was a watershed for moving us toward real-time participation in warfighting. Yet this transition is ongoing; we are still far from complete integration. With new systems entering the fight, such as Joint STARS, space assets and UAVs, we must again ask "*How will they play?*" I was often frustrated with late-night mission planning sessions, brainstorming with fellow officers about how we could best use all available assets to improve situation awareness and targeting. In every case, we had to develop new tactics, techniques and procedures (TTP) for platform integration. Our TTP manuals could not keep pace with emerging technology.

I wrote this paper to stimulate thought towards developing a systematic, analytical approach for creating optimized target engagement constellations. The model I propose, however, is just a stepping stone for additional analysis for one of the most dynamic issues facing the warfighting community today. The intent of this research is not to identify one sensor as better than another, or one engagement constellation as better than another; rather, it is to encourage warfighters to think in terms of optimizing the employment of all platforms. I hope to encourage commanders to think in terms of "constellations of systems," which will maximize targeting potential and effects, when establishing time-critical targeting.

I would like to express my thanks to several folks who continuously challenged me with "Defend yourself!" Majors John Sellers, John Miller, and Tom Ruby, Lieutenant Colonel Kim Sievers, Commander Robert Gaines, Captain Henry Cyr, and Mr. Cameron Danskine, did everything possible to ensure an excellent and well-researched product. Also, Majors Randall Vogel, Don Finley, Jeff Lutes and Joseph Harvey provided invaluable sensor data and critiques of the concepts contained within this paper. Any research shortfalls I claim as mine alone, despite their best efforts.

Abstract

This research project will develop a model that describes how we acquire, designate and engage a time-critical target. Very rarely do U.S. Air Force aircraft operate independently. F-15Cs integrate with E-3 AWACS for counterair while F-16CJs and RC-135s coordinate for suppression of enemy air defense. Shooters and sensors continuously interact to put weapons on target. Developments in modern warfare place a premium on the timeliness and accuracy of this interaction. And yet current operational and tactical integration of sensors and shooters is extremely haphazard; successful integration and target engagement is primarily due to random innovation. Sensor-to-shooter relationships require more analysis and a documented systematic approach to optimize current and future operations.

In this thesis, I analyze the targeting data sent from sensor to sensor and from sensor to shooter. Specifically, I focus on how systems interact in order to employ weapons on a target, and what contributions each system makes to the entire target engagement process. From this analysis, I develop a model for the way we conduct near-real time targeting, from first detection to final target engagement. This time-critical targeting (TCT) model reveals five functions that must be fulfilled whenever we attempt target engagement. Highlighting these five functions—detect, locate, identify, fuse and disseminate—allows us to measure each platform's ability to participate in target engagement.

The TCT model lends itself to the development of a battle management tool called the TCT matrix. This matrix allows us to systematically identify, evaluate, and exploit sensor-to-sensor-

to-shooter relationships for use in theater campaign execution. Using this battle management tool, a commander may select specific platforms from the entire "universe" of sensors and shooters, to create specific target engagement "constellations" of sensors and shooters able to engage desired targets. The matrix allows us to select optimum constellations, based on the timeliness and accuracy necessary for time-critical targeting. This matrix could also give the commander a means to monitor real-time the status of his time-critical targeting capability as platforms plug in and out of the "constellation." It also enables planners to adapt to new technologies or targeting needs by providing them with a tool for developing future targeting constellations.

This model should not be limited to USAF assets, or even air assets—it can be expanded to include any theater component commander's targeting "constellations." However, due to research limitations, I shall focus on the air war and the responsibilities of the Joint Force Air Component Commander (JFACC) to optimize the interaction of his air assets. I will also focus on the time-critical targeting (TCT) scenarios often observed during the initial "Halt Phase" of a conventional conflict as this is when most current USAF doctrine postulate air power could have the greatest impact. The use of air power for targeting during military operations in urban terrain (MOUT) or military operations other than war (MOOTW) are also important, and fall under the TCT model. Specific discussion of MOUT and MOOTW, however, is beyond the scope of this research.

Part 1

Introduction

The ... dangers of failure in the preconcentrated action of widely separated portions of the army is now almost completely removed by the electric telegraph.

—Lt Gen Rudolf von Caemmerer, 1905

Almost a century ago, Lt Gen Caemmerer believed Field Marshal von Schlieffen's German general staff had discovered a technological solution to the problem of conducting warfare at the operational level. That struggle continues today. At the strategic level, *Joint Vision 2010* dictates that the US military must use technology and information superiority to maintain our advantage over potential adversaries.[1] Additionally, Air Force Doctrine Document 1 (AFDD-1) *Air Force Basic Doctrine* defines two of our core competencies as information superiority and precision engagement.[2] Yet the tactical level Air Force Tactics, Techniques, and Procedures (AFTTP) 3-1 manuals, a series of documents describing how each weapon system is employed, do little to address information superiority or precision engagement. There appears to be a gap between our strategic and operational doctrine and our tactical employment manuals. Where is the connection at the operational level of war that informs us how to put all of these assets together to achieve the dominant battlespace knowledge (DBK) intended by our doctrine?

To bridge this gap, we must focus on building a "universe" of systems that maintains information superiority; DBK cannot be obtained with single, isolated systems. With such a universe of systems, theater commanders maintain situation awareness and optimize their ability

to target an adversary's key capabilities. We currently have examples of successful sensor-to-shooter "constellations" (specific sensor and shooter combinations, out of the entire universe of systems, that integrate their information for target engagement). The E-3 AWACS and F-15C work together in the air-to-air role. The F-16CJ and RC-135V/W Rivet Joint (RJ) are refining their interaction to improve suppression of enemy air defenses (SEAD). As good as these pairings are, they were developed on an ad hoc basis, around a mission planning table. Is there not a more structured method that would allow a commander to systematically devise such constellations?

A commander requires such a battle management method for several reasons. First, building and evaluating sensor-to-sensor-to-shooter constellations uses the strengths of one system to overcome the weaknesses of others—multiple system integration enhances accuracy. Second, efficient targeting constellations speed up the time from initial detection to final engagement of a target—from sensors to shooter—allowing our military forces to gain and maintain the initiative. Finally, effective targeting constellations help prevent targeting mistakes. In today's environment (described in Section II), we cannot afford to engage the wrong target; the military, political and diplomatic repercussions of incorrect targeting can be immense. We must ensure our target engagement is as accurate and timely as possible. What we need, then, is a model to describe how platforms interact to create targeting information, that can be used to systematically hone both our accuracy and timeliness of our targeting process.[3]

In Section III, I will develop such a model to describe the sensors and shooter interaction needed throughout the target engagement process. Using this model, a commander may optimize sensor and shooter interaction for missions within his area of operations by ensuring the appropriate platforms are in-theater and on-station to produce the desired effects. The model

also helps the commander rapidly recognize what capabilities he will lose when a system drops out of the constellation, and which assets he can use in its place to regain the desired capability.

This model can also be used in a proactive manner, before any forces deploy to a theater. Rather than the theater commander's "do the best with what we've got" approach, planners can use modeling simulations and tests to develop targeting constellations prior to deployment or the generation of an operation plan (OPLAN). The TCT matrix described in Section IV is an adaptation of the TCT model to provide commanders and planners with a battle management tool for optimizing targeting constellations. Section V discusses how exercise planners using the TCT matrix can proactively identify which constellations will work, and focus time and resources on training those constellations in target engagement. When a crisis erupts, these constellations are then ready to operate together immediately upon entering the theater due to effective training and standard operating procedures. Testing and acquisition based on this model can identify shortfalls that degrade the effectiveness of these constellations, and begin programs to correct the shortfalls.

This model could be expanded to include any theater component commander's targeting constellations. Due to research limitations, I shall focus on the air war and the responsibilities of the Joint Force Air Component Commander (JFACC) to optimize the interaction of his air assets. I will also focus on time-critical targeting (TCT) often used during the initial "Halt Phase" of a conventional conflict as this is when both AFDD-1 and AFDD-2 postulate air power could have the greatest impact.[4] The use of air power for targeting during military operations in urban terrain (MOUT) or military operations other than war (MOOTW) are also important, and fall under the TCT model. Specific discussion of MOUT and MOOTW, however, is beyond the scope of this research.

[1] Chairman of the Joint Chiefs of Staff, *Joint Vision 2010* (Purple Book), July 1999, 16.

[2] Air Force Doctrine Document (AFDD) 1, *Air Force Basic Doctrine*, 1 September 1997, 30-31.

[3] Throughout this research, I will be referencing both precision and accuracy. American Heritage Dictionary (1982 edition) defines accuracy as "the state or quality of being correct;" while precision is defined as "the state or quality of being strictly distinguished from others." Granted, these terms seem to be synonymous, and in some cases may be interchangeable. Throughout this paper, however, when referring to "accuracy" I will be focusing on correctness—is the identification correct? Yes or no. When using the term "precision" I will be discussing the magnitude of target location error for a particular measurement—is a location measured to within feet, or miles? When using the phrase "timeliness and accuracy," I am incorporating both definitions given above into the single term "accuracy."

[4] "*In this view of warfare, the halt phase may be planned as the conflict's decisive phase, not as a precursor necessarily to a build-up of ground forces. The point of the 'decisive halt' is to force the enemy beyond their culminating point through the early and sustained overwhelming application of air and space power.*" AFDD-1, 42. Also, during the Halt Phase, "*aerospace power is capable of denying an enemy the ability to offensively employ his forces.*" AFDD-2, *Organization and Employment of Aerospace Power*, 28 September 1998, 21. Proactively, "*by wresting the initiative, setting the terms of battle, establishing the tempo of operations, and taking advantage of tactical and operational opportunities, air and space forces can defeat the adversary's strategy.*" Ibid., 5.

Part 2

Background

Doctrine is our formal, traditional, highly respectable method for institutionalizing past mistakes.

—Mr Cameron Danskine, 2000

Why Our Target Engagement is Changing

Successful American military operations are dependent on obtaining information and targeting superiority over the adversary. The manner in which US armed forces have maintained information and targeting superiority in military operations has evolved over the past few decades. Up through the 1980s, our approach to air warfare was one of force-on-force combat against a comparable Soviet military.[1] We determined where the targets were, prioritized them, determined how best to strike them, and relied on technology to keep us ahead in a war of attrition.[2] Since then, we have shifted emphasis from "out-attritting" toward outthinking and outmaneuvering the enemy in a high ops tempo war to achieve battlespace dominance in this post-Cold War period.[3] Our current doctrine now dictates asymmetric use of aerospace power to apply our strength against an adversary's weakness.[4] Information enhances our ability to outthink the adversary and employ force in a more timely and accurate manner. The current emphasis on timeliness and accuracy results from several different external developments: advanced technology, increased mobility of targets, increased political risk, and decreased

resources. I'll briefly examine these developments, as they are the impetus for developing the time-critical targeting (TCT) model.

Technology. Advances in technology allow us to increase the tempo of warfare, and maintain information superiority.[5] Advances in the accuracy and timeliness of sensors, the quantity of data presented on cockpit displays, and the capability of voice and data links allow more information to pass between assets.[6] Information is now exchanged between sensors, and from sensor directly to shooter.[7] Decreasing the time from detecting targets to engaging and destroying targets decreases our decision cycle, thus allowing us to maintain the initiative in military operations.[8] We are making great strides to address Col. John Boyd's premise to shrink our own decision loop and to make our decisions faster than our opponents.[9]

Mobility. Meanwhile, our potential adversaries plan to counter our doctrine and capabilities.[10] Potential targets are now more mobile and thus more difficult to detect and locate. Our difficulty in destroying the Iraqi SCUD missile launchers during Operation DESERT STORM demonstrated our inability to integrate sensors to find and target mobile targets within the traditional 72-hour air tasking order (ATO) mission planning cycle. This cycle is now considered by many to be obsolete[11] By the time intelligence/surveillance sensors spotted the SCUDs, and the warfighting community began to mission plan for strikes against them, the launchers had moved to a new location. Such timely target information *"proved to be just too difficult to obtain."*[12] We had to come up with new tactics to counter this threat. Such engagements, whether we call them "time-critical targeting," "flex targeting" or engaging "targets of opportunity," involve several basic functions: sensors first detect, then locate and identify the target. This information must then be disseminated to a shooter who will engage before the adversary can react (by "shooter," I am referring to any asset that applies force on a

target, be that using hard-kill weapons, electronic warfare, or information warfare methods). All of this must happen within minutes; using the normal 72-hour ATO targeting cycle would create lost opportunities.

Political Risk. The political environment has also changed. The American public is now averse to risking the lives of American servicemen and, in fact, is becoming more averse to excessive casualties inflicted against the opponent as well. Popular support for involvement in conflict quickly evaporates in the face of excessive casualties or fratricide caused by incorrect targeting.[13] We observe this in several recent examples: the accidental destruction of an Iranian airliner in 1988;[14] the mistaken shoot-down of U.S. Army Blackhawk helicopters in northern Iraq in 1994;[15] and the unintentional targeting of the Chinese embassy in Belgrade in 1999.[16] The administration's aversion to political repercussions from such incidents drives our use of precision weapons, our targeting practices, and our rules of engagement (ROE). It is a challenging dilemma: do we minimize the risk of our own pilots by encouraging ROE such as beyond visual range (BVR) engagements, or do we increase risk to ensure these engagements are accurate and don't produce unacceptable enemy, non-combatant or friendly casualties. To address this dilemma, we continue to move towards maximizing accuracy in order to achieve the desired military effects while minimizing the risk of casualties.

Limited Resources. This emphasis on precision is also driven by our limited assets. Fiscal restraints limit the number of systems we may employ against a target.[17] General Charles A. Gabriel, as the Air Force deputy chief of staff for plans and readiness, predicted in 1979: "*In future conflicts, our weapons must be employed selectively and with precision because we are force limited.*"[18] Therefore, we must hit the target and create the desired effect the first time, while risking a minimum amount of assets. Economy of force also requires us to depend on

multiple assets working together to engage a target.[19] Appendix A provides additional background and support to explain why we are moving to multiple system constellations.

These four external developments force us to integrate and operate in new ways to ensure timeliness and accuracy for target engagement. Maj. James Marshall, in "Near-Real-Time Intelligence on the Battlefield" summarizes this progress: "*Interoperability of sensors, communications, intelligence processing, and data displays... better sharing of information... will lead to more accurate and timely targeting information, new targeting opportunities, and a greater likelihood of weapons on target.*"[20] Constellations that work together to engage targets in a time-critical manner will enable us to fight this new fight. Our doctrine is taking us in this direction.

Both *Joint Vision 2010* and *Air Force Basic Doctrine* echo these expectations of the future battlefield. These two documents recognize that improved precision and a higher tempo of operations will be fundamental to future conflicts. According to *Joint Vision 2010*, information superiority is critical to modern warfare: "*dominant battlespace awareness will improve situational awareness, decrease response time, and make the battlespace considerably more transparent to those who achieve it.*"[21] One of the new operational concepts of *Joint Vision 2010* is "precision engagement," which stresses our ability to integrate systems to locate desired targets, and then provide situation awareness to command and control (C2) assets and shooters who employ weapons to produce the desired effect upon that target.[22]

AFDD-1 reflects this emphasis, concentrating specifically on Air Force capabilities to achieve this desired state of speed and precision. Aerospace power, as outlined in AFDD-1, is uniquely able to obtain and maintain information superiority to achieve precision engagement: "*Our overwhelming ability to observe our adversaries allows us to counter their movements with*

unprecedented speed and agility" and thus "*dictate the tempo and direction of an entire warfighting effort.*"[23]

Both of these documents outline our final destination towards speed and precision. Yet the strategy for arriving at this destination remains incomplete. Two existing concepts help us to design a TCT model to bridge this gap between where we are and where we want to go. First, Col. John Boyd's "OODA loop" (also known as the decision cycle) represents how a "system" should be adaptive to a changing environment, in order to observe, orient, decide and act at a faster rate than the adversary (appendix B). By obtaining more information about the battlespace, discerning our opponent's actions and intentions, and then acting before he can react, we maintain the initiative in battle. The second concept is the combat identification (CID) matrix (appendix C), employed by the E-3 AWACS and fighters in the counterair role to ensure compliance with a theater's ROE.[24] The CID matrix describes the targeting functions required for an air-to-air engagement.

Unfortunately, these concepts fall short of addressing how to conduct time-critical targeting at the operational level. The OODA loop emphasizes minimizing the decision cycle, but is not specific enough to resolve operational targeting problems such as building targeting constellations. The CID matrix is too specific, focusing exclusively on air-to-air combat at the tactical level.

Filling the Gap

A coherent model is needed to represent the time-critical targeting (TCT) process, as a means of analyzing current and future weapons systems integration for the operational level of warfare. A JFACC must know what functions need to be accomplished to conduct TCT, and then know which sensors are required to fulfill these functions. This model must therefore

represent those functions necessary for conducting TCT across the spectrum of operations, as well as factors that influence those functions. The model must reflect our emphasis on timeliness, accuracy, and interoperability of systems. Satisfying these requirements will enhance our ability to engage targets according to our current doctrine, namely using information and precision to outpace our adversary, to engage increasingly mobile targets, while accounting for increased political risk and decreased resources.

Notes

[1] Such as the joint attack of the second echelon [J-SAK] operational doctrine put forward by USAF's Tactical Air Command and the Army's Training and Doctrine Command in the early 1980;s "*designed against the specific threat of echeloned attack posed by Soviet tactical doctrine.*" Lt Col William F. Andrews, *Airpower Against An Army* (MAFB, AL: AU Press, 1998), 16-17. Similarly, NATO's follow-on forces attack [FOFA] doctrine developed in the 1980s "*to bolster the alliance's conventional capability against Soviet offensive doctrine*" focused on attacking Soviet second echelon mechanized forces. Andrews, 17. By comparison, "*air and space power is providing the 'scalpel' of joint service operations—the ability to forgo the brute force-on-force tactics of previous wars and apply discriminate force precisely where required.*" AFDD-1, 30. Also: "*This focus* [by targeting manuals] *on destruction results from two traditional concepts of war—annihilate an enemy through outright destruction, or exhaust an enemy before he exhausts you (attrition). An alternative concept of warfare... to render the enemy useless is just as effective as eliminating the enemy force itself in terms of securing favorable conflict termination.*" Col David A. Deptula, "Firing for Effect: Change in the Nature of Warfare," in *Aerospace Operations ACSC Coursebook* (MAFB, AL: AU Press, 2000), 52.

[2] "*TAC* [Tactical Air Command] *concentrated on achieving air superiority over the battlefield and employing airpower in support of ground forces—a consuming challenge. Especially because NATO's doctrine of Follow-On Forces Attack depended on air and ground forces working together to defeat the superior numbers of the Warsaw Pact without first resorting to nuclear weapons.*" Rebecca Grant, "Closing the Doctrine Gap," in *Aerospace Operations ACSC Coursebook*, (MAFB, AL: AU Press, Feb 00), 18.

[3] "*Improvements in information and systems integration technologies will also significantly impact future military operations by providing decision makers with accurate information in a timely manner. The fusion of all-source intelligence with the fluid integration of sensors, platforms, command organizations, and logistic support centers will allow a greater number of operational tasks to be accomplished faster.*" *Joint Vision 2010*, 13. Also: "*Merging our increasing capacity to gather real-time, all-weather information continuously with our increasing capacity to process and make sense of this voluminous data builds the realm of dominant battlespace knowledge* [DBK]. *Likewise, our growing capacity to transfer DBK to all our forces, coupled with the real-time awareness of the status of all our forces and the*

understanding of what they can do with their growing capacity to apply force with speed, accuracy, and precision, builds the realm of 'near perfect' mission allocation." Adm William A. Owens, "Dominant Battlespace Knowledge," in *Aerospace Operations ACSC Coursebook*, (MAFB, AL: AU Press, 2000), 343.

[4] AFDD-2, 8.

[5] "*Information superiority efforts include attempts to develop the ability to consistently react to a situation and make accurate decisions more rapidly than the enemy. This places increased strain on enemy leaders and forces, eventually causing shock at unexpected events which increases the 'friction' of war. Dominating the information spectrum not only improves the speed and quality of our observe-orient-decide-act loop (OODA-loop), but also significantly degrades and influences the adversary's cycle time as well as the quality of their information and ultimately, shapes the adversary's perception of the situation and courses of action.*" AFDD-1, 32.

[6] "*In view of advances in technology and the accelerated speed of modern warfare, there is an increased demand and operational capability for near-real-time combat information support on the tactical battlefield.*" Maj James P. Marshall, *Near-Real-Time Intelligence On The Battlefield* (MAFB, AL: AU Press, 1994), 1.

[7] "*Organic capability will allow for direct flow of information from collection to warfighter via analyst. In certain fast moving situations, the requirement exists for intelligence information to go directly from collector to warfighter or in current parlance, 'sensor-to-shooter.*'" Maj Mark E. Marek, *Can ATARS Fix America's Tactical Reconnaissance Vacuum*? USMC Command and Staff College, (Quantico, VA: Marine Corps University, 1995), n.p.

[8] "*To seize the initiative, the commander must have near-real-time intelligence to get inside his opponent's decision cycle and make the enemy react to our plan.*" Marshall, 5.

[9] "*Dominating the information spectrum not only improves the speed and quality of our observe-orient-decide-act loop (OODA-loop), but also significantly degrades and influences the adversary's cycle time as well as the quality of their information and, ultimately, shapes the adversary's perception of the situation and courses of action.*" AFDD-1, 32. Also: AFDD-2, 15.

[10] Using SEAD as an example, Lt. Col. Brungess warns us our opponent's ever-increasing capabilities must drive us to reshape how we engage in war: "*The speed with which a modern enemy IADS* [Integrated Air Defense System] *adapts to attack poses some special problems for the intelligence community—especially as it relates to collection, assessment, and dissemination. Collection equipment must be able to pinpoint emitters and data transmission arrays in real-time. Assessment of enemy intentions and capabilities must be quick, accurate, and disseminated rapidly to SEAD strategists, tacticians, and users. Timely data—real-time data—is crucial to the development of a clear picture of the enemy net.*" Lt Col James R. Brungess, *Setting the Context: Suppression of Enemy Air Defenses and Joint War Fighting in an Uncertain World* (MAFB, AL: AU Press, 1994), 169.

[11] According to Air Force Chief of Staff Merrill A. McPeak, "*It is a disgrace that modern air forces are still shackled to a planning and execution cycle that lasts three days.*" Gen. Merrill A. McPeak, "For the Composite Wing," *Airpower Journal* 4, no. 3 (Fall, 1990): p. 7, as quoted in Maj. James P. Marshall, *Near-Real-Time Intelligence On The Battlefield*, (MAFB, AL: AU Press, Jan 94), p. 66. Also, "b*ecause required information, once collected, frequently arrived too late to be useful, planners had to use out-of-channel work-arounds to assess*

combining results within the 72-hour planning cycle." Thomas A. Keaney and Eliot A. Cohen, *Gulf War Air Power Survey: Summary Report* (Washington, DC: Dept Air Force, 1993), 140-141. In Col Edward C. Mann III, *Thunder and Lightning: Desert Storm and the Airpower Debates* (MAFB, AL: AU Press, 1995), 151.

[12] Ibid.

[13] "*The will of the people as expressed through public opinion and governmental power structures has modified the ways in which military force can be applied.*" Brungess, 3.

[14] In 1988, while conducting operations in the Persian Gulf, the *USS Vincennes* mistakenly shot down an Iranian airliner, killing all 290 passengers on board. President Reagan publicly expressed "deep regret" for what he called a "terrible human tragedy" and the U.S. government compensated the victims' families and the Iranian government for their losses. This incident further soured relations between the two countries, and is still an emotional issue for Iranians. "Muting Anguish in Iran Over '88 Air Disaster," *New York Times*, 4 July 1998.

[15] "*A razor-thin margin between successful 'kills' of enemy aircraft and the tragedy of fratricide remains a stubbornly persistent feature of modern warfare. Missiles of all sorts—air-to-air, surface-to-air, and air-to-surface—have grown ever more reliable and lethal. Yet combatants must still make split-second shoot/no-shoot decisions in order to be effective, and under the extraordinary pressures of combat environments, those decisions remain open to fatal error. The tragic downing of two U.S. Blackhawk helicopters by a pair of U.S. F-15Cs in the 'no-fly zone' over northern Iraq on 14 April, 1994, which resulted in the deaths of all 26 people on board the Blackhawks, goes far to illustrate the difficulties of reliably separating friend from foe in beyond-visual-range missile engagements.*" Barry D. Watts, *Doctrine, Technology, and War,* Air & Space Symposium on 30 April-1 May 1996 (MAFB, AL: AU Press, 1996), n.p.

[16] Another incident, the accidental bombing of the Chinese embassy in Belgrade, Yugoslavia by three GPS-guided bombs from a B-2 bomber in May of 1999, caused a firestorm of diplomatic and political protest from China and Russia. The bombs hit the intended target; however, faulty CIA information led NATO to target the wrong building. At least three Chinese citizens were killed, with at least twenty wounded. This incident occurred at a crucial time, when negotiators were working toward a settlement acceptable to the Russian government. Both China and Russia issued harsh protests; Russian President Boris Yeltsin claimed to the bombing was "a blatant outrage, and there can be no justification for it" and warned of "very harsh consequences" for continued bombing of Serbia. Chinese citizens protested outside American government offices in China. China called an emergency meeting of the United Nations Security Council to denounce both NATO and the United States for the incident. The Security Council refrained from issuing a statement of condemnation, but members did express their "shock and concern." Summarized from several articles of the *New York Times*: Jane Perlez, "U.S. Tries to Limit Policy Damage From Bombing of China Embassy," 8 May 1999; Michael R. Gordon, "NATO Says It Thought Embassy Was Weapons Depot," 9 May 1999; Celestine Bohlen, "An Outrage, Yeltsin Declares, and Warns of 'Consequences,'" 9 May 1999; and Eric Schmitt, "Aim, Not Arms, at the Root of Mistaken Strike on Embassy," 10 May 1999. All of this demonstrates how fragile the political and diplomatic landscape can be, and how even one mistake in the targeting process might force major national shifts in policy.

[17] In their report on intelligence successes and failures during DESERT SHIELD/STORM, the House Oversight and Investigations subcommittee stated: "*The services had retired intelligence platforms purely for budgetary reasons without providing sufficient means to fill in*

the holes in coverage... decisions to retire intelligence assets, or otherwise curtail intelligence capabilities, should only be made after the impact on intelligence has been fully considered." U.S. Congress, House, Oversight and Investigations Subcommittee, Committee on Armed Services House of Representatives, Intelligence Successes and Failures in Operations Desert Shield/Storm, 103rd Cong., 1st sess., 1993,Committee Print, 9. As quoted in Marek, n.p.

[18] Gen Charles A. Gabriel, "Tactical Reconnaissance for the 1980s," *Signal,* October 1979, 9 as quoted in Marshall, 2.

[19] "*We must be able to cross-cue sensors to optimize target coverage, eliminate duplication, and avoid deception.*" Marshall, 3.

[20] Ibid., 108.

[21] *Joint Vision 2010*, p. 13.

[22] Ibid., 21.

[23] AFDD-1, 24.

[24] Rules of engagement (ROE) are "*directives issued by competent military authority which delineate the circumstances and limitations under which United States forces initiate and/or continue combat engagements with other forces encountered.*" Joint Pub 1–02, *DOD Dictionary of Military and Associated Terms*, 29 June 1999. Reference Air Force Tactics, Techniques, and Procedures Manual 3-1, Volume 15, *E-3 AWACS Concept of Operations* (Secret) for a classified discussion of the E-3 AWACS Combat Identification Matrix. Information extracted is unclassified.

Part 3

The TCT Model

I'm just looking for a better way to kill the bad guys.

— Major John Sellers, 2000

The current void in the time-critical targeting process requires a functioning model which incorporates environmental factors and optimizes employment of scarce assets. This new time-critical targeting model is a combination of previous targeting concepts and personal experience in theater operations. The TCT model uses the CID matrix as a baseline and expands its scope beyond the air-to-air realm to include all forms of targeting. Highlighting the fundamental intent of each step in the CID matrix, we can identify essential functions for targeting. The model can then be optimized for both speed and precision, incorporating the premises of Boyd's OODA loop. The TCT model provides us with a method for determining optimum targeting constellations. With these relationships identified, the model concentrates on how the JFACC may construct sensor constellations to provide his shooters with the quickest response to meet desired accuracy. It is this capability that bridges the gap between our tactical capabilities and our doctrine for information superiority and precision engagement. We begin by determining the key elements of the targeting process.

Functions of the TCT Model

There are five functions of the time-critical targeting process used by theater intelligence, surveillance and reconnaissance (ISR) assets, command and control (C2), and shooters to designate and engage any enemy target. The first three functions—detection, location, and identification—are used to designate a target. These three functions can be accomplished *by* any number of sensors. These sensors are designated as either active (possessing an onboard radar used to detect reflected emission returns) or passive (collecting emissions produced by the enemy).[1] The last two functions, fusion and dissemination, are necessary for correlating data from the first three functions to create targeting information then passed to a shooter for engagement. Fusion takes place *between* the sensors, while dissemination takes place *between* sensors, C2, and shooters, with operators interacting via voice or data link. These five functions are further defined in the following paragraphs.

a. Detection (Figure 1).

The first function in the TCT process is for a sensor to detect a contact of interest (a COI, or any data collected by a sensor that may begin the targeting process). We cannot engage something unless we somehow know it is out there. Both active (energy emitting) and passive (emission collecting) sensors can detect COIs. Detection can be a radar return from an active sensor such as an E-3 AWACS or an AEGIS cruiser. A COI can also be detected passively, for example by a SIGINT sensor (such as an RC-135V/W Rivet Joint, or RJ) that detects an enemy aircraft's radar emissions or a visual observer spotting an enemy aircraft's contrails. The characteristic which determines detection capability is a wide field of view (FOV) in whatever spectrum the sensor is operating. For example, a UAV may have a very detailed electro-optical sensor, but its flight parameters, range and airspeed may limit its FOV with respect to geographic

coverage, and hence its ability to detect COIs.[2] Similarly, some aircraft have very precise SIGINT receiver systems but don't scan through the entire frequency spectrum rapidly enough to be used as search and detect systems—again, a limited FOV. Therefore, a sensor with a wide FOV has the best probability of detecting COIs.[3]

Figure 1. The Detect Function.

b. Location (Figure 2).

The second function in the process is to locate the COI and produce coordinates for engagement.[4] If the contact is moving, then this function must also produce an airborne or ground "track" (a COI's location as it moves with time).[5] All subsequent action is based upon this location or track, so the JFACC should employ those sensors best able to build the most precise locations. For example, active sensors with high resolution radars, such as Joint STARS, build much more precise locations on a surface-to-air missile battalion than a passive sensor such as an EP-3E Aries II signals intelligence (SIGINT) aircraft.[6] Active sensors, then, are preferable for detection and location of COIs.

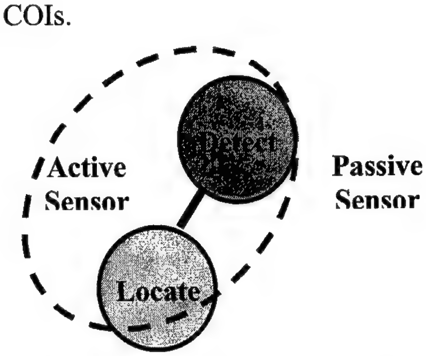

Figure 2. Detection and Location – Active Sensors.

c. Identification (Figure 3).

The third function is to identify the COI. An active sensor may be able to provide this type of information (with very precise radars of high resolution, such as synthetic aperture radars). However, passive sensors, such as imagery satellites and SIGINT assets, specialize in the identification of COIs. Experienced operators using accurate, sensitive collection equipment can correlate current observations of the battlefield to historical databases. Such sensors may differentiate between friendly and enemy surface-to-air missile launchers, or distinguish enemy fighter jets from civilian airliners. In some situations, the required identification accuracy is high. Knowing a COI is an adversary aircraft may not be enough; we may need to know it is an adversary *fighter* aircraft before we engage.

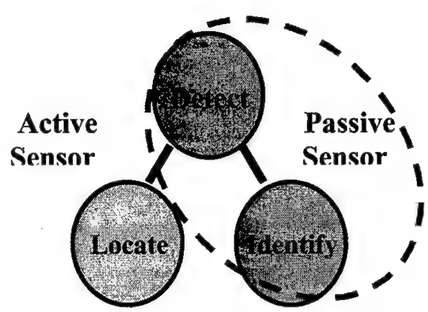

Figure 3. Detection and Identification – Passive Sensors.

The identify and locate functions do not have to occur sequentially, they can occur in parallel. On individual platforms, the functions may be performed in sequence. Active sensors will likely detect and locate simultaneously (see Figure 4). For example, an AWACS radar detects and locates an airborne track simultaneously. The crew must then work toward identifying the track as a possible target. Passive sensors, such as an RJ, work in reverse. They detect and identify the COI, and then work toward building a location precise enough to pass on

to other theater assets. By using multiple sensors, we can perform the locate and identify functions simultaneously, thus reducing the amount of time to produce targeting information. Tying the location function to the identification function is fusion.[7]

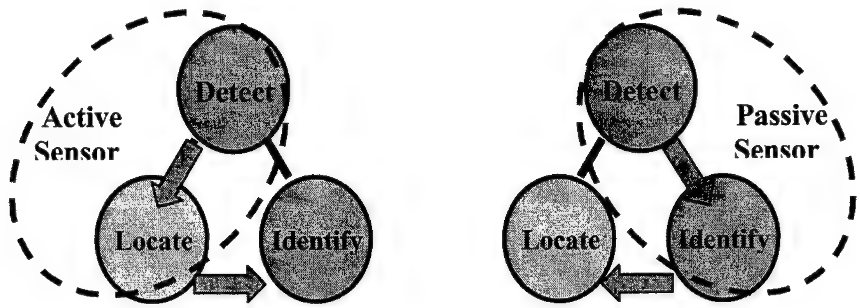

Figure 4. Active vs. Passive Sensor Determination of Targets.

d. Fusion (Figure 5).

Fusion is the process of combining the data gathered during the detect, identify and locate functions to develop targeting information. This can occur with a single aircraft, such as an A-10 pilot visually acquiring, and then engaging, an enemy tank. In doctrine, however, fusion usually refers to the interaction of multiple sensors, such as when an AWACS and RJ correlate information about an enemy fighter.[8] It is the fusion of information from multiple sensors that provide the synergy of multi-sensor targeting relationships, using the strengths of one system to overcome the weaknesses of another.

The fusion function encompasses both the means, such as voice/data links,[9] as well as the methods, or the tactics, techniques and procedures (TTP) used by aircrews to communicate and correlate information. But the actual fusion of data is performed by people, not by systems or sensors.[10] Knowledgeable operators on intelligence, surveillance, and reconnaissance (ISR)

platforms (such as AWACS, Joint STARS and Rivet Joint) perform much of the fusion process, associating bits of information with other bits, while incorporating both current and historical information. Rapid exchange of information between operators on different platforms builds a common picture of the battlespace. When targeting information is incomplete, for example when the identity of a COI is still unknown, then operators turn back to their sensors to further refine the information. Data links, such as TADIL-J/Link 16 and future wide-band data link concepts[11] show great promise for enabling fusion—all systems in the data link, including the shooters, may eventually share a common battlespace picture.[12] This will depend greatly on platform dissemination capability.

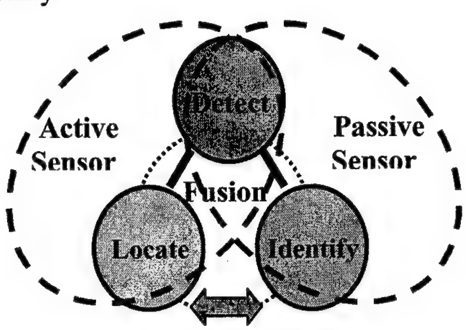

Figure 5. Fusion.

e. Dissemination (Figure 6).

The dissemination function is the link between sensors and shooters, and occurs when the final targeting information is passed to command and control agencies and the shooters for possible engagement. Like fusion, this function encompasses equipment such as voice/data links and real-time information into the cockpit (RTIC) displays, as well as the TTPs used by aircrews to pass this targeting information. Using these means, command and control can decide to engage reactively (such as when the air operations center, or AOC, receives information on a new target and directs the shooter to engage) or proactively (using ROE that specify which

targets will be engaged, if found). To be of any use, however, this targeting information must be disseminated in a format useful to the decision maker (to decide whether or not to engage) and to the shooter (to engage the target, if so directed). For example, passing geolocation coordinates to a pilot who is working with a theater central reference point (known as "bullseye") is of limited tactical use.[13] This highlights the distinction between fusion and dissemination: fusion converts incomplete data into targeting information, while dissemination passes the complete targeting information to decision makers and shooters.

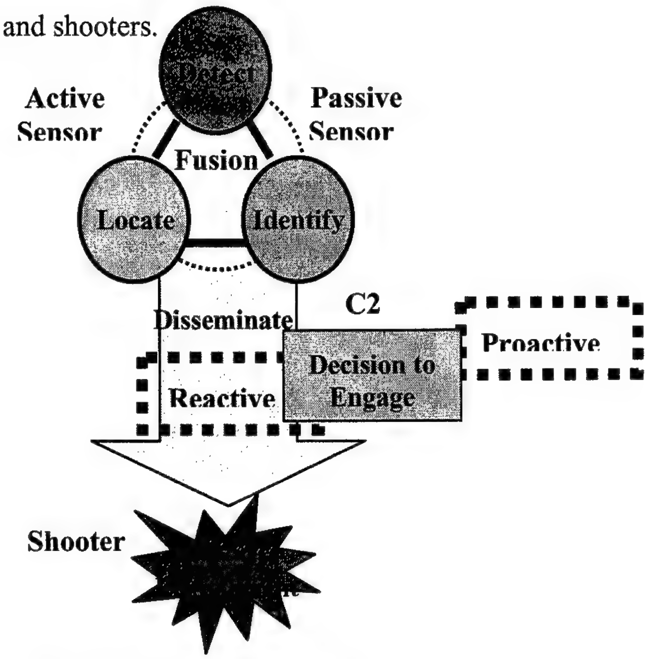

Figure 6. Dissemination.

Once the target information is disseminated to the shooter, is it useful? How precise a location do I need? How accurately must I identify a target before I can engage it? These are questions a JFACC must address before conflicts begin, and the answers must be clearly spelled out in theater ROE and special instructions (SPINS). There are several factors that determine the precision required within the TCT process. Once we know the required precision, the model highlights which systems provide that precision.

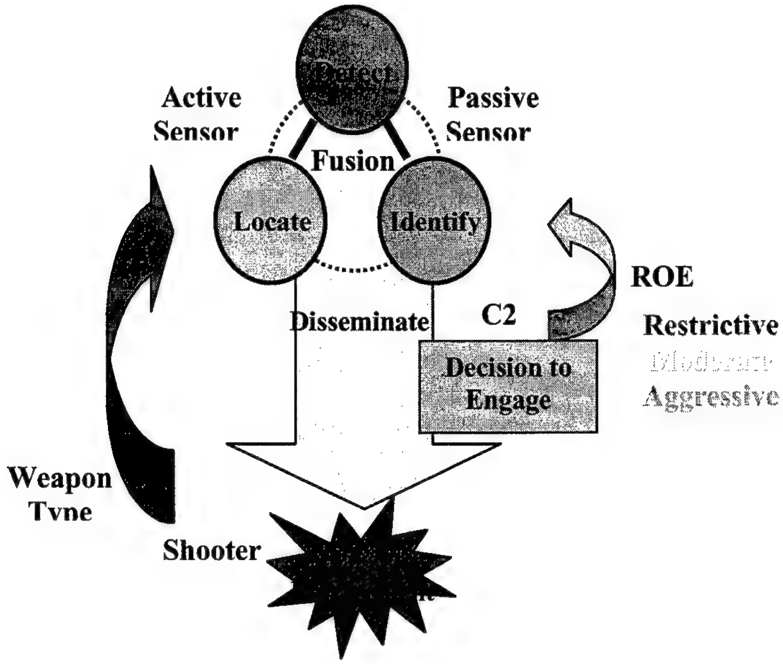

Figure 7.. Precision Factors—Weapon Type and ROE.

b. Rules of Engagement (Figure 7).

While weapon type drives location precision, it is the ROE that determine the level of accuracy required by the identification function of the TCT model. Command and control directs shooters to engage targets according to theater ROE and target identification. Identification is ROE-dependent and may not have to be precise. Aggressive ROE, employed when political or military repercussions for mistakes are low, may allow commanders to use procedural methods to identify a hostile target. Kill boxes, free fire zones, no-fly zones, guilt-by-association, and point of origin guidance may not require much sensor accuracy to identify a contact as a hostile target. In other cases, moderate or even restrictive ROE may be necessary to minimize the risk of collateral damage or fratricide. Thus, as the risk of unintended consequences increases, the precision required for identification increases. JFACCs must recognize this correlation, understanding that when they make the ROE more restrictive, they must match this with sensors capable of obtaining the precision required for identification.

Let's look at an example of how a JFACC may influence target engagement using precision factors (see Figure 8).[15] The target is a surface-to-air missile (SAM) site. How the JFACC wishes to engage this target determines the choice of weapons, and hence the sensor required to perform the locate function. If the JFACC wishes to engage with a jammer, location need not be precise. If the JFACC prefers to engage with high-speed antiradiation missiles (HARMs), or even with precision guided munitions (PGMs), then the precision required for the target location increases, and the required sensor may change. Meanwhile, ROE may be such that a COI can immediately be "identified" as a hostile target and engaged (e.g., aggressive ROE may direct shooters to engage any convoy of five vehicles or morer, or anything moving out of a specific cantonment site). If the ROE is restrictive, then a sensor must accurately identify the COI as a target, or the pilot must visually identify the target (unfortunately increasing the risk to the pilot). As the JFACC's acceptance of risk changes, so too does his ROE level, and the sensors required to fulfill the identification function.

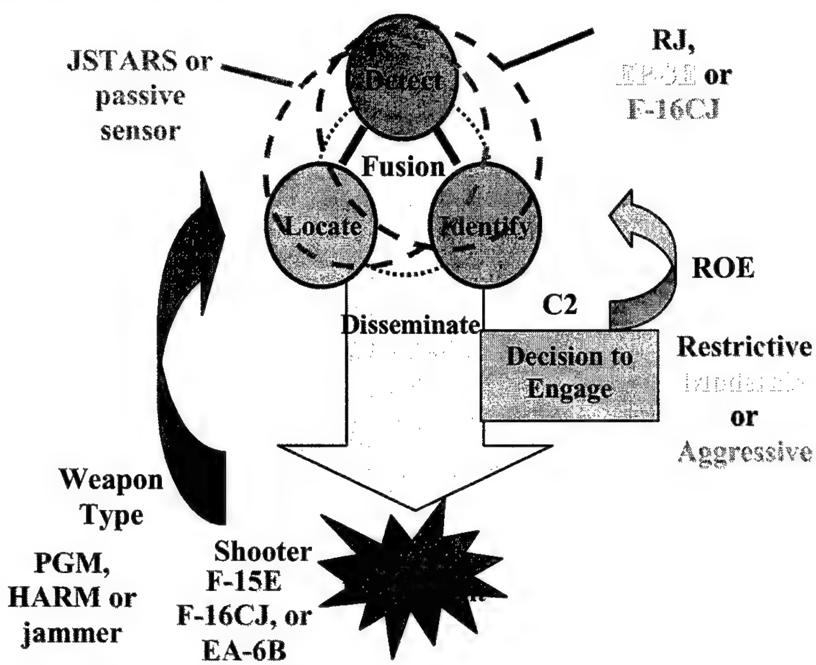

Figure 8. Engaging a Surface-to-Air Missile Site.

Summary

The proposed model is designed to bridge the gap between doctrine and employment. Using the OODA loop and CID matrix as a foundation, the model expands to include all time-critical targeting engagements. Five targeting functions and two precision factors are instrumental to describing any targeting scenario. Of these, the detection, location and identification functions are accomplished by sensors. The precision required in the location function is driven by the type of weapon being employed. The accuracy required in the identify function is driven by theater ROE. Fusion takes place among sensors to complete the targeting information, which is then disseminated to C2 and shooters. The platforms which work together to accomplish all the targeting functions may be termed a "targeting constellation." The TCT model not only describes existing targeting constellations, but also predicts future constellations. In the next section, we will use the model to optimize existing, or create new, targeting constellations.

Notes

[1] Many authors have categorized systems in various ways. Air Vice-Marshal Tony Mason lists "*four major classes of sensors and platforms: specialist aircraft, multirole aircraft, UAVs, and satellites.*" Air Vice-Marshal Tony Mason, *The Aerospace Revolution: Role Revision & Technology - An Overview* (London: Brassey's, 1998), 83. Maj William G. Chapman describes three different categorization methods for sensors: national, theater, or tactical; systems grouped by type of intelligence provided (i.e., SIGINT, IMINT, ELINT, etc.); and finally his preferred categorization of sensors into space systems, aerial systems, and surface systems. Maj William G. Chapman, *Organizational Concepts for the "Sensor-To-Shooter" World: The Impact of Real-Time Information on Airpower Targeting* (MAFB, AL: AU Press, June 1996), 23-24. These categories fail, in my opinion, because they focus on the sensor's 'state-of-being' and not on what function the sensor provides to the targeting process.

[2] Air Vice-Marshal Tony Mason, *Brassey's Air Power: The Aerospace Revolution* (London: Brassey's, 1998), 95.

[3] Some systems do not detect, and yet are still valuable to the targeting process. Intuitively, this may not make sense—how can a sensor locate and identify a threat without first detecting it? We must return to our characteristic for good detection, namely a wide field of view. A Predator

UAV may use its imaging sensors to precisely locate and identify a SCUD launcher, but with the limited FOV of its sensors, it could spend hours flying over the Iraqi desert before finding the launcher. Ibid. A sensor with a much greater FOV, such as a Joint STARS, can initially detect the COI and direct the UAV in for a closer look to more accurately identify and locate the target. [The Predator "*can supplement the sensors of the larger systems by searching radar shadow and monitoring radio and radar emissions at a very low level.*" Ibid.]. In the same regard, an EC-130H Compass Call can take advantage of an EP-3E Aires II's wide FOV and rapid search of threat frequencies when searching for ground-controlled interceptor sites. Using the initial target information from off-board sensors, the Compass Call then builds a much more accurate identification and location (in frequency) with its own sensors. In both cases, a sensor with a wide FOV detects the COI and gives a rough location or identification to another platform. The second platform of the team refines the information so the threat can be targeted.

[4] "*Geolocation accuracy is a crucial requirement for target acquisition, especially with the employment of precision-guided munitions. Reconnaissance and surveillance may not require pinpoint accuracy, but TA* [target acquisition] *requires a sensor suite that ultimately produces a target location or air point suitable to support the munitions chosen to attack the targeted systems.*" Joint Publication 3-55, *Doctrine for Reconnaissance, Surveillance, and Target Acquisition Support for Joint Operations*, 14 April 1993, II-4.

[5] "*Track (the electronic computer 'tag' given an aircraft that has detected, located and is being tracked).*" Brungess, 168.

[6] Air Vice-Marshal J P R Browne and Wing Commander M T Thurbon, *Brassey's Air Power: Electronic Warfare* (London: Brassey's, 1998), 208-210.

[7] "*For the foreseeable future, battlefield sensors will not be able to look at all information at the same time in sufficient detail. Thus, the sensor system will need to use a combination of cueing, filtering, and pinpointing (e.g., as a JSTARS system does to indicate a group of moving vehicles so UAVs can be dispatched to identify each of them).*" Martin C. Libicki, *What is Information Warfare?* Center for Advanced Concepts and Technology, Institute for National Strategic Studies, (Washington DC: National Defense University, August 1995), n.

[8] The role of 'fusion' is described in AFDD 2-5.2 as "*ISR-derived information from many sources… combined, evaluated, and analyzed to produce accurate intelligence. Fusion also helps overcome the inherent limitations of friendly collection systems that inhibit the ability of a single source to provide adequate information for decision-making. Fused information from multiple sources provides the user with a more complete picture of the battlespace.*" AFDD 2-5.2, *Intelligence, Surveillance, and Reconnaissance Operations*, April 1999, 11.

[9] Such as the Tactical Digital Information Link (TADIL)-A/Link-11, TADIL-J/Link-16, and Tactical Information Broadcast Service (TIBS).

[10] Although with increasing technology, there is no reason why this fusion could not be automated in the near future, using artificial intelligence constructs.

[11] DOD directed Joint Airborne SIGINT Architecture, or JASA, is a new effort to require all airborne reconnaissance aircraft migrate to JASA compliance by 2010. Currently, "*DOD airborne collection platforms do not operate under a common architecture and are limited in their ability to exchange data among platforms for the purpose of rapid signal triangulation for geolocation and targeting.*" "Intelligence Resource Program," *Federation of American Scientists, n.p.: on-line, Internet, 20 February 2000*, available from http://www.fas.org/irp/program/collect/rivet_joint.html.

[12] *"The better the interoperability of systems and the more robust and redundant the links, the better the cross-cueing, analytical exchange, and ability of the commander to work inside an opponent's decision loop.*" Joint Publication 3-55, II-5.

[13] Shooters and ISR assets often use different reference systems for location. Fighter pilots often use a range and bearing call based on magnetic north from a set reference point, or bullseye. ISR assets often work with coordinates based upon latitude and longitude, while varying among platforms when reporting a bearing referenced to magnetic versus true north. When such a reference discrepancy exists, communication between these assets is extremely difficult and time-consuming.

[14] Again, the term "shooter" includes any system that may apply force to a target, whether it is a hard kill with bombs and bullets, or a soft kill using electronic or information attack. Therefore, to "engage" the target includes using any of these methods.

[15] For additional examples of how the TCT model describes current targeting constellations, see appendix D.

Part 4

Applying the TCT Model

You should not have a favorite weapon. To become overfamiliar with one weapon is as much a fault as not knowing it sufficiently well. It is bad for commanders ... to have likes and dislikes.

—Miyamoto Musashi, 17th century

TCT Model for the Joint Force Air Component Commander

Although the model seems focused at the tactical level, it is not about tactics. It is about optimizing the use of assets to satisfy time-critical targeting throughout an operational theater.

a. The Joint Force Air Component Commander (JFACC) and the TCT Model.

When preparing an air campaign, a JFACC can use the TCT model to ensure appropriate platforms are included in his plan, prioritized in the time-phased force and deployment data (TPFDD),[1] and available for employment. The JFACC can use this model to ensure all required targeting functions are being satisfied.[2] It does little good, for example, to have a Joint STARS aircraft (to detect and locate) with shooters on station without a sensor capable of the third targeting function of the model, identification.

The JFACC can also use the TCT model to designate replacement platforms if the primary system fails, for example, replacing an RJ with a comparable EP-3E to fulfill the identification function. The JFACC must also be aware of individual asset limitations and targeting

constellation shortfalls. The best constellation of sensors is useless if they cannot disseminate the targeting information to a shooter because of incompatible data links or voice channels. Finally, the JFACC must realize that besides using different sensors and shooters, he may also change the effectiveness of targeting constellations by changing the type of weapons employed or the ROE.

This occurs because employing precision weapons places a greater demand on obtaining precise target locations that may exceed the location capability of some sensors (see Figure 9). The use of broad area weapons, such as jammers or antiradiation missiles, requires less precise location data, and thus more sensors can be used in targeting constellations to achieve this level of location precision. Similarly, loosening the restrictions on ROE, and thus decreasing the precision required for the identification function, again opens up the potential for using more sensors for targeting constellations. On the other hand, enforcing strict ROE increases the level

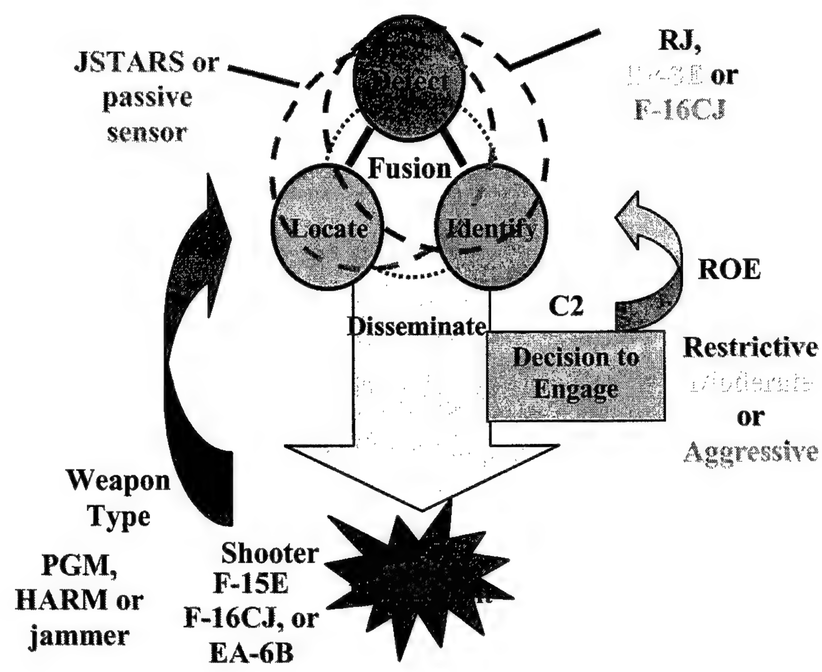

Figure 9. JFACC's Impact on Targeting Constellations.

of precision required for identification, and thus targeting constellations are limited to those few platforms that can achieve this precision. In summary, the JFACC, by changing the ROE or use of precision weapons, can drastically affect the employment of targeting constellations.

The TCT model was developed to optimize current and potential constellations between two or more systems to detect, locate, identify and engage time-critical targets. Every platform has strengths and weaknesses inherent in its ability to fulfill the five TCT model functions. Active sensors, such as those aboard AWACS, Joint STARS, AEGIS or PATRIOT, generally do well at detecting and locating COIs; however, they often lack the ability to identify these tracks as threats. Passive sensors, such as those aboard the RJ, EP-3E and RC-12, are able to detect COIs and identify them as threats; however, they may not have the ability to locate the threat with sufficient precision for weapons engagement. Certain shooters, such as F-16CJs and EA-6Bs, and other sensors, such as UAVs, may be able to locate and identify a COI as a target, but cannot quickly detect the target due to a limited field of view. Developing a battle management tool based on the TCT matrix allows us to recognize what each system provides to the target engagement process, and allows us to create sensor-to-shooter constellations optimized to detect, locate, identify and engage targets.

b. The TCT Matrix as a Battle Management Tool.

Based on our TCT model, we can create a useful battle management tool called the TCT matrix (see Figure 10). This matrix allows a JFACC or AOC staff to quickly identify and evaluate the optimum targeting constellation for a given scenario, using critical path analysis. Critical path analysis is a technique for systematically determining the optimum "path" through a system, based on changing variables (in time-critical targeting, time and precision are those variables). The critical path indicates the targeting constellation that goes from detection to

target engagement in the shortest amount of time, while maintaining required location and identification precision. Along the vertical axis of this matrix are listed the shooter and the sensors that might make up various targeting constellations supporting target engagement. The targeting functions—detection, location and identification—are measured on this tool by timeliness and accuracy, the most desirable characteristics of time-critical targeting. Each sensor is evaluated on its ability to detect a contact of interest, how quickly it locates the contact to sufficiently engage it with the proposed weapon, and how accurately the sensor identifies the contact as a viable target. Because various sensors have different capabilities, there may be significant cross-cueing of data between the sensors, but only if they share fusion and dissemination links.

To use the TCT matrix, planners begin by using the two precision factors: the JFACC's ROE and the required location precision for the weapon. They then determine the target in Step 1. The target drives the JFACC's choice of weapon to employ against the target (Step 2), and the weapon determines the location precision required for that weapon (Step 3). This location precision correlates to the time it takes for a given sensor to build a target location for the required precision (generally, as time passes, sensors will build a more accurate location on a contact of interest). This correlation of time and location precision is demonstrated by the location bar key along the top of the matrix, called the target location error (TLE),[3] which measures location precision and generally gets smaller with time.[4] The TLE is shown in the location bar key to indicate a COI has been initially detected, and located to less then 10NM, less than 1NM, less then a quarter mile, less than 100 feet, and finally to less than 10 feet. Some sensors will be able to locate COIs to the required precision more rapidly than others. This will be displayed by a shortened location bar.

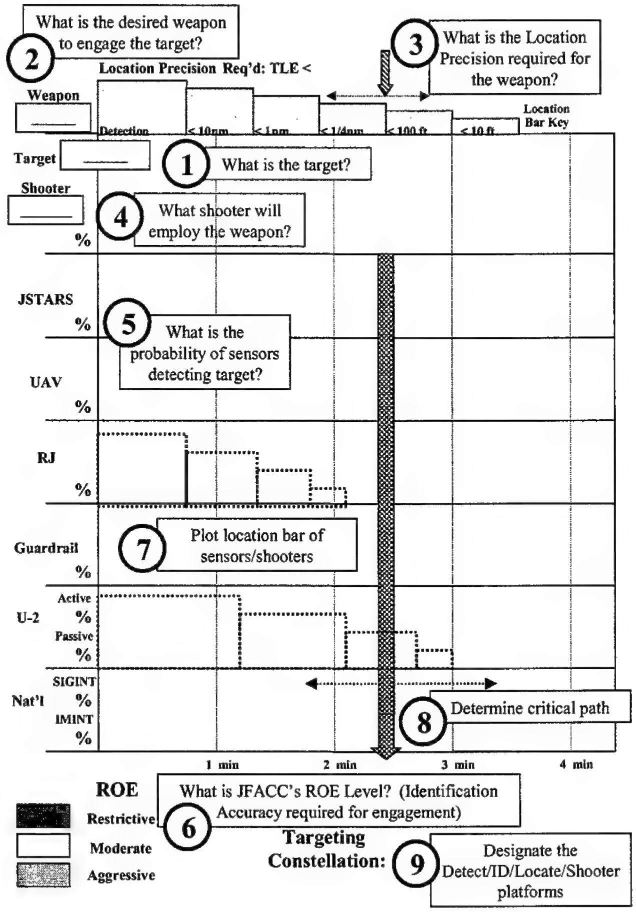

Figure 10. The TCT Matrix.

Planners then input the shooter engaging the target (Step 4). This decision should be based upon such factors as whether a shooter has an ability to employ the desired weapon, connectivity with sensors, the capability to independently detect the target, and is available in-theater. Step 5 indicates the probability that a sensor or shooter will detect the given target along the vertical axis. This value will reflect the FOV of the sensor with respect to the target.[5] In Step 6, planners indicate the ROE level for identification accuracy required by the JFACC—either aggressive, moderate, or restrictive.[6] If the environment demands restrictive ROE, this requires greater

identification accuracy. The various levels of identification accuracy are color-coded in the matrix. If the ROE is restrictive, then only paths that fulfill this level of identification accuracy may be followed.

Step 7 is the heart of the matrix, displaying for each sensor and shooter the time and precision capability against the target. Planners consider the ability of each sensor to locate the intended target, and plot this capability as a location bar along the horizontal axis. As time passes (moving right on the matrix), and the target location becomes more precise, the location bar will become smaller. Planners can then measure the time it will take for each sensor to locate the target to the required location precision. If a sensor is unable to locate a particular type of target—for example, a SIGINT aircraft is unable to locate a tank—then there would be no sensor location bar for that target. The sensor's ability to identify the target is reflected in the color-coding of the location bar.

Planners then create "paths" through the sensors and shooters to achieve all the requirements for engagement (namely, ensuring all targeting functions are met). Planners must remember, however, that fusion and dissemination may only take place between sensors and shooters if they possess shared communications capability. The TCT matrix may indicate many paths that meet both location and identification accuracy requirements. However, critical path analysis reveals one targeting constellation that meets the precision requirements in the shortest amount of time (Step 8). This critical path can also be referred to as the "method of optimized sensors/shooters employment" (MOOSE). Both terms refer to the platforms that form the most effective targeting constellation (Step 9).

c. TCT Matrix Examples.[7]

Evaluating Constellations. Using the matrix in an example will further clarify its applicability. In this scenario, an F-16CJ will engage a SAM radar site with HARMs. We expect passive sensors to have a higher probability of detecting radar energy of a SAM, as shown by higher detection percentages compared to platforms with more limited FOVs. The following figures show we can take many paths to work our way through the matrix from first detection to final target engagement. Critical path analysis will determine the quickest path that meets the ROE criteria, indicating the targeting constellation most desirable for time-critical targeting of a SAM.

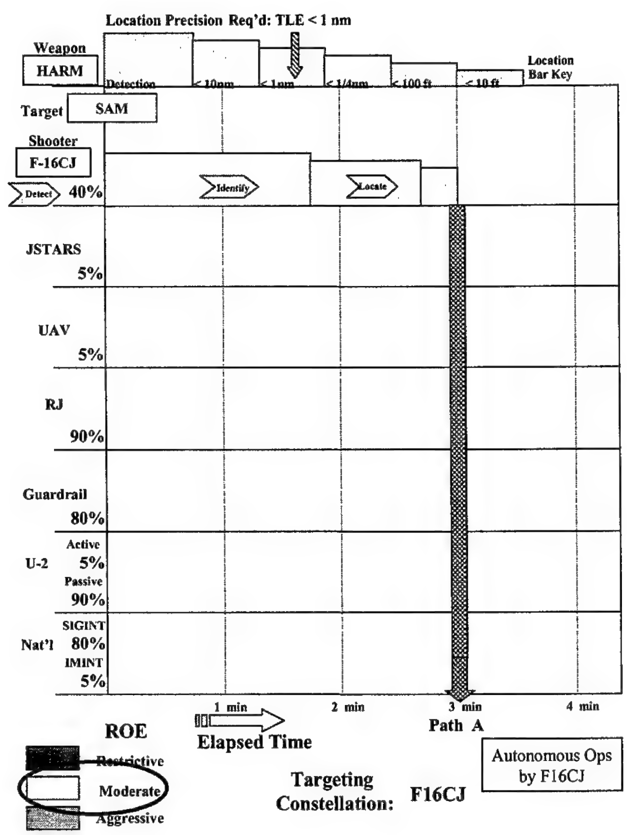

Figure 11. TCT Matrix: Autonomous Ops by F-16CJ.

An F-16CJ is capable of independent operations, as shown by Path A in Figure 11, and perhaps this is the quickest time from detection to target engagement. However, due to the F-16CJ's limited ability to identify targets, ROE may restrict SAM engagement until a more thorough identification is obtained (for example, a restrictive ROE that requires multiple platform concurrence on identification). Also, due to the F-16CJ's limited FOV (and lower probability of detecting the target), the JFACC may find creating a targeting constellation speeds up the detection process.

The critical path formed by the RJ and F-16CJ seems to provide the optimum targeting constellation for SAM engagement (Figure 12). With its wide sensor FOV, and its multiple trained analysts and precise data measurement capability, the RJ has exceptional ability to detect and identify SAMs. There are two possible paths: the RJ can pass a rough location of the SAM, once detection and identification are complete, allowing the F-16CJ to refine the SAM location prior to engagement (Path B); or the RJ can wait until it has built a location to the precision required by a HARM, and then disseminate the complete targeting information to the shooter (Path C). Voice and data link (using the improved data modem, or IDM) provide the means for fusion and dissemination. Either path matches the JFACC's restrictive ROE requirement (because the RJ has performed the identification function in both cases). Both provide the required precision—it is just a matter of choosing which asset performs it quicker, the RJ or the F-16CJ.

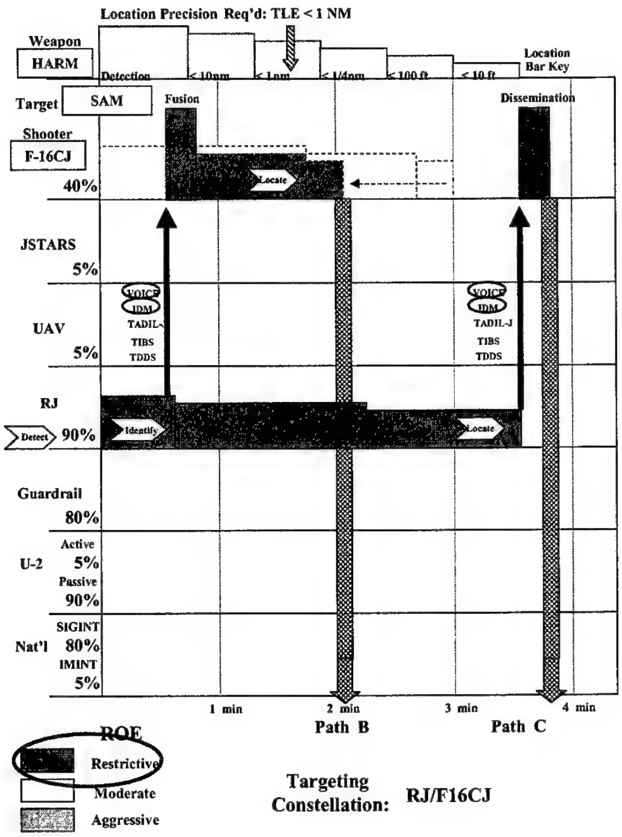

Figure 12. TCT Matrix: RJ/F-16CJ Targeting Constellation.

After testing and evaluation of this targeting constellation, we may discover that Path B is the quickest, and therefore most desirable, targeting constellation. The JFACC may then emphasize this targeting constellation when engaging SAMs, ensuring these platforms are flying during risk-prone missions that might face SAMs. Theater SPINS would direct RJ crews to disseminate SAM information early, and allow the F-16CJ to fuse this information with onboard location sensors to refine the SAM location.

Constellation Shortfalls. We also observe shortfalls. Identifying these shortfalls early prevents a JFACC from relying on targeting constellations that will not satisfy all necessary TCT functions. We observe in Figure 13 that the RC-12 Guardrail has a very high probability of

detecting the contact and accurately identifying the contact as a SAM. Its method of locating contacts (often using three aircraft) also quickly allows it to locate the SAM to the required location precision. The first three functions of the TCT model are met. Unfortunately, doctrine and lack of voice or data links prevents disseminating the RC-12 data to the F-16CJ. This path, Path D, will not be successful, and therefore useless to a JFACC for targeting. We must fall back on the targeting constellation of RJ and F-16CJ, which satisfies all targeting functions of the TCT model in the quickest time.

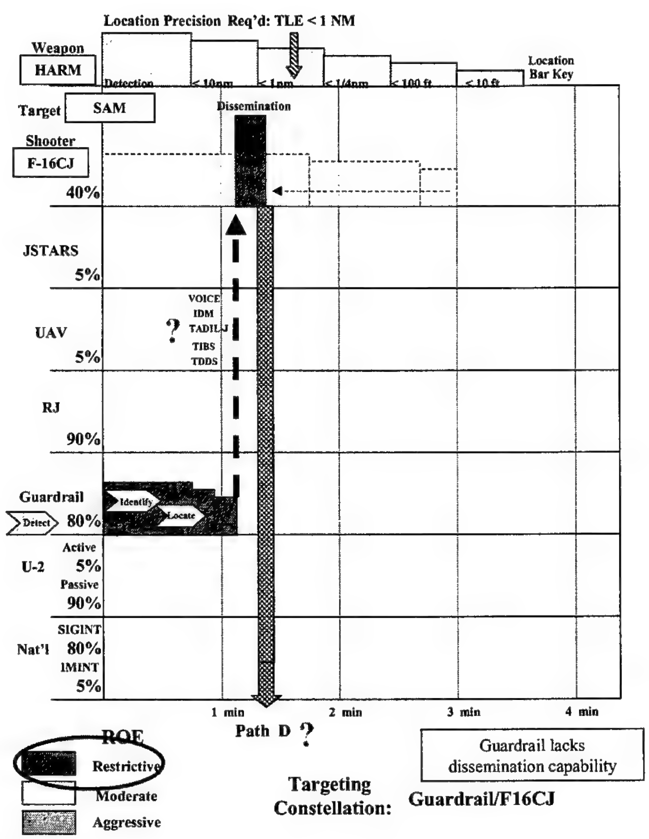

Figure 13. TCT Matrix: Guardrail/F-16CJ, A Failed Targeting Constellation.

Another shortfall is shown by Path E in Figure 14. This path shows TADIL-J connectivity between the RJ and Joint STARS, but a lack of IDM connectivity between Joint STARS and the F-16CJ. [8] Dissemination depends solely on voice connectivity, rather than the faster, less ambiguous, data links. With TADIL-J connectivity, the RJ might send a rough location to the crew of a Joint STARS who, with their active sensor, may precisely locate the SAM in much less time. With IDM connectivity, Joint STARS could then relay precise location information to the F-16CJ. Path E shows the constellation formed by the RJ, Joint STARS, and finally the F-16CJ. Again, lack of dissemination capability indicates a shortfall in a possibly promising constellation.

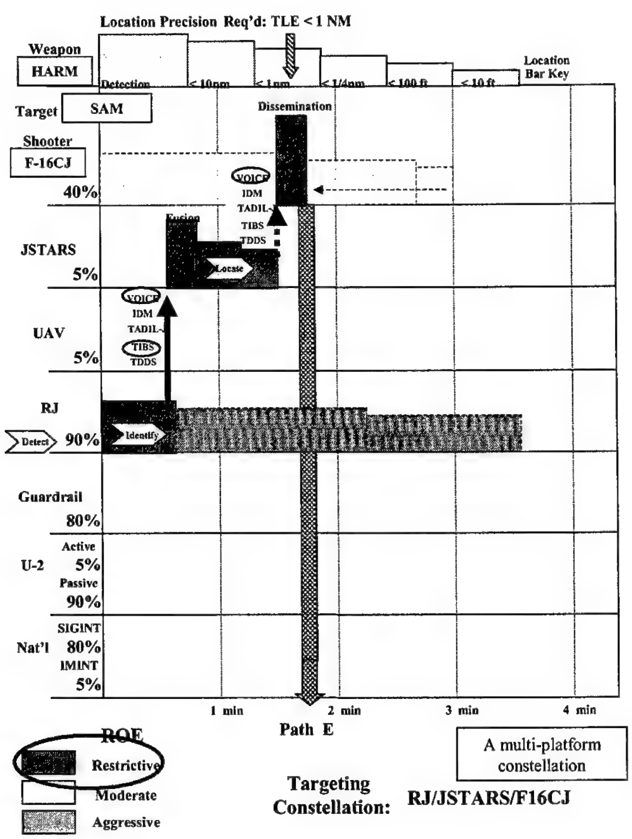

Figure 14. TCT Matrix: RJ/Joint STARS/F-16CJ Targeting Constellation.

Once these shortfalls are identified, a JFACC may develop "workarounds." The first move might be to seek to correct the shortfall. This may or may not be within the power of the JFACC to correct, depending on the nature of the shortfall. For example, if dissemination is the shortfall, time constraints may prevent the JFACC from improving data link connectivity during a specific crisis. Yet other shortfalls may be corrected by the JFACC. If available, the JFACC can employ other constellations that do not share the shortfall. New TTPs might be developed to mitigate the shortfalls, such as when new communications procedures are developed to make up for the lack of data links. There are many options available to a JFACC and his staff that would address constellation shortfalls, but only if these shortfalls are known.

Real-Time Updates. For this reason, the JFACC needs to know which constellations are not working, and why. More importantly, perhaps, the JFACC needs to know how the constellation shortfall impacts his ability to engage time-critical targets, and what he can do to correct the problem. This need is most apparent when a JFACC loses a sensor from his existing constellation. The TCT matrix displays the impact of such losses. A computer simulation of the matrix could provide real-time updates to a JFACC, continuously reporting on the condition of the targeting constellation.

For example, Figure 15 shows the impact of losing an RJ from the SAM engagement constellation (if, for example, the RJ has goes off-station). As discussed previously, the F-16CJ can operate autonomously (Path A, Figure 11), but the JFACC may seek another means to retain the restrictive ROE. Using the TCT matrix, a JFACC may see the impact on SAM engagement of substituting an EP-3E for the RJ. Path F shows the critical path formed by the EP-3E and F-16CJ. Comparing Path F with the RJ's Path B illustrates for the JFACC the loss in timeliness with this new constellation, if the ROE remains restrictive (identification accuracy remains high).

It also illustrates the shortfall of no IDM connectivity, and highlights the fact that voice communications procedures will have to be implemented.

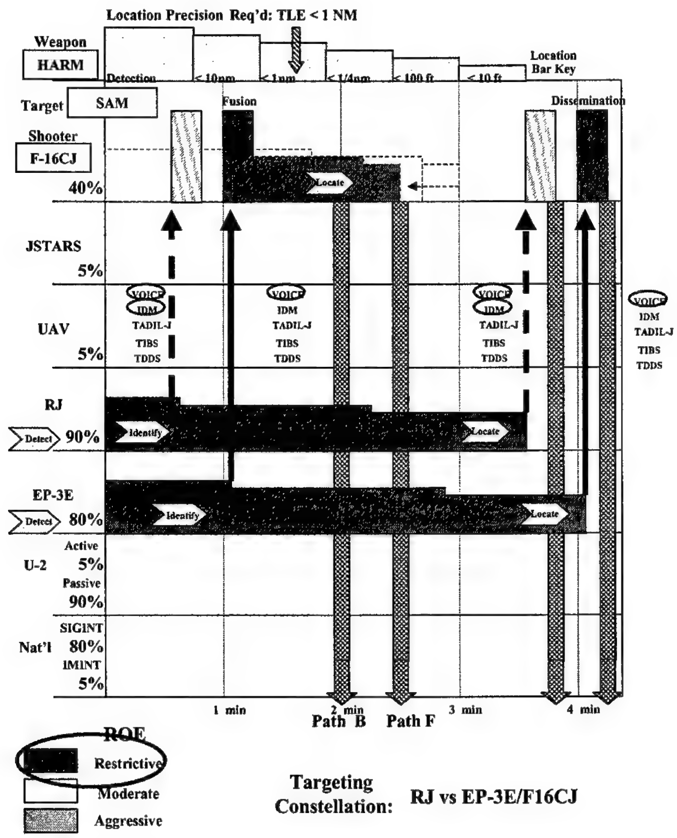

Figure 15. TCT Matrix: Impact of Replacing Sensors.

The JFACC now has a tool to receive real-time updates on the status of his targeting constellations. With the TCT matrix, the JFACC observes the condition of his constellations. He also sees the impact of losing a system, or substituting one platform for another. With it, he can work through difficult platform selection dilemmas and determine if the available constellations meet the required timeliness to engage the target. While gaining a robust view of his current capability (approaching the desired DBK) he can also use the TCT matrix to predict future targeting constellations.

TCT Model to Predict Future Targeting Constellations

The JFACC has at his disposal a vast array of weapons. Using AFTTP 3-1s, he can employ these weapon systems in tried and true methods. Yet existing targeting constellations risk being too slow or inaccurate for weapons employment in tomorrow's environment. If technology is continually advancing system capabilities, the JFACC needs to continuously develop new targeting constellations. The TCT model allows him to predict successful constellations and disregard unsuccessful ones.[9] Pairing of the RJ and F-15C highlights this ability.

RJ/F-15C. An insufficient number of E-3 AWACS (the traditional partner of F-15Cs) in-theater could reduce counterair capability. A JFACC may need to look to new targeting constellations to fill the gap. Although the RJ has never worked directly with F-15Cs, our model envisions them working together in the air-to-air mission (Figure 16). The RJ scans with its wide FOV, detects enemy COIs and identifies them as targets, and passes rough locations to the

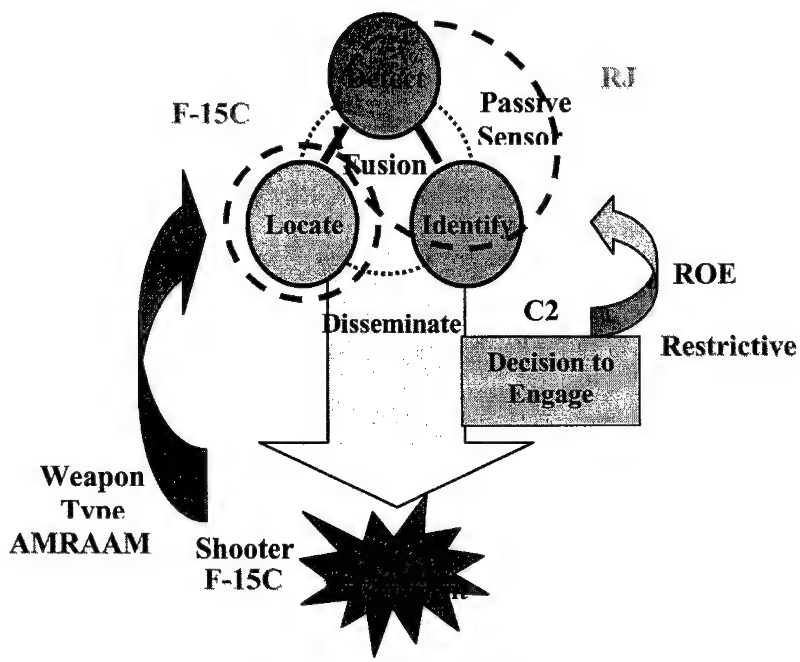

Figure 16. RJ/F-15C.

F-15C. The F-15C refines this target location with its own radar to engage beyond visual range. The JFACC now has a new targeting constellation to fulfill the counterair mission.

RJ/RJ/F-16CJ. We can also use the TCT matrix to examine how future constellations may improve a JFACC's ability to engage targets. Many agencies are currently looking at multiple-sensor programs to increase timeliness and accuracy.[10] These efforts go beyond cross-cueing, and enter the realm of cooperative sensor interaction. In such programs, the sensors don't exchange different pieces of the puzzle—they work cooperatively to find all the pieces of the puzzle. One example is the "Network-Centric Collaborative ISR" plan being investigated by the AC2ISR office.[11] Theoretically, all five targeting functions will be dramatically increased. Path G, Figure 17, shows the expected constellation of two RJs conducting cooperative collection.[12]

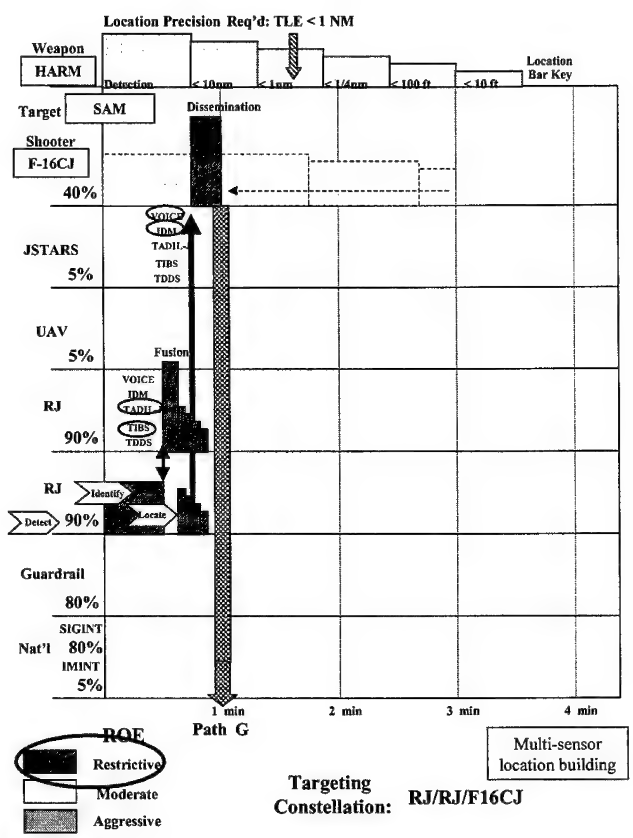

Figure 17. TCT Matrix: RJ/RJ/F-16CJ Targeting Constellation.

Summary

In this section, I examined how the JFACC, or his staff, may employ the TCT model and matrix. The TCT matrix is used to plot the capabilities of various sensors to detect, identify, and locate targets, and then to fuse or disseminate this targeting information to other platforms. Using critical path analysis, the JFACC may determine the optimum constellations to engage the target, and employ his forces to take advantage of these constellations. TCT matrices such as these should be constructed for each weapon and possible target, and incorporated into a computer model. Such computer modeling of the TCT matrix could highlight to a JFACC the impact on timeliness and accuracy that might result from a loss of any platform. The JFACC thus has real-time assessment of the capability of his current airborne forces to engage time-critical targets, as various assets plug in and out of the constellation.

If existing targeting constellations do not meet the JFACC's requirements, then new ones may be necessary. These new targeting constellations may satisfy current JFACC needs, and improve both timeliness and accuracy of the time-critical targeting process. However, we cannot hope to employ these new targeting constellations without proper testing, evaluation, planning and training. This requires use of the TCT model by others beside the JFACC and will be highlighted as a recommendation in the next section.

Notes

[1] The TPFDD is the Joint Operation Planning and Execution System data base portion of an operation plan (OPLAN). Among other things, it lists units to be deployed to support the OPLAN with priority, and indicates the desired sequence for their arrival in theater. Joint Publication 4-0, *Doctrine for Logistic Support of Joint Operations*, 27 January 1995, GL-9.

[2] Most likely, these specific duties will fall on the JFACC's staff or a designated representative, such as the AOC Director, or ISR Battle Management Element in the Combat Operations Division of the AOC. "*The ISR Battle Management Element is the single focal point for integration and real-time synchronization of ISR assets with ongoing/planned aerospace*

operations." According to the Combat Aerospace Forces Concept of Operations for Command and Control of Intelligence, Surveillance, and Reconnaissance Operations (draft), 25 October 1999, 18. Yet it is important the JFACC realize there are methods to optimize target engagement.

[3] Various sensors have different terms for this measure of location precision, usually depending on the mathematical algorithms used to calculate the location. Two common terms are circular error of probability and error ellipse.

[4] This statement is a very general rule of thumb. Active sensors build COI locations almost instantaneously; the accuracy depends upon the resolution of the active sensor. Passive detectors build locations by triangulating emissions from the target; this process takes time. As time passes, this triangulated location generally becomes more precise, until a sensor-specific threshold is met—the limitation of the sensor. Beyond this point, additional time will not aid the location precision of the passive sensor.

[5] With advanced computer modeling, this would include all variables that affect a sensor's ability to detect a target. These would include sensor variables: sensor FOV, scan strategies, scan revisit rate, scan time, altitude, orbit, distance from the target, loiter time, etc. Also, there are target variables: construction material (metal versus wood), target shape, reflectivity, size, mobility, camouflaging, emitting versus non-emitting, etc. Finally, there are environmental variables: weather, terrain, time of day, etc.

[6] I have designated only three ROE "levels." "Aggressive ROE" represents an environment requiring less identification accuracy, such as that found during DESERT STORM when kill boxes were set up along the Iraqi lines of communication and relatively unrestricted free-fire zones were in place. Engaging aircraft "because they are north of the border, so they must be bad" is another example of "aggressive ROE." "Restrictive ROE" would exist in a politically sensitive environment in which identification accuracy is paramount before target engagement. The stringent confirmation procedures used in operations over Bosnia and Kosovo would be examples of "restrictive ROE." "Moderate ROE" would lie between them in the ROE spectrum, similar to the ROE often employed in Southwest Asian theater in which strict identification requirements are applied unless friendly aircraft are threatened. Although I describe three levels, a JFACC may designate any number of ROE levels.

[7] For these examples, the location precision required by each weapon; the sensor probability of detection; and the time required to achieve a given location precision are all notional values. Detailed testing and evaluation must be conducted to determine the true values.

[8] Since mid-1998, Rivet Joint and Joint STARS aircrews have used voice communication procedures for sensor-to-sensor fusion of information. Only since late 1999 have the Rivet Joint and Joint STARS been able to communicate digitally with common TADIL-J messages (using the J3.5 Land Point/Track and J6.0 Intel Information message sets). As of this writing, we have yet to significantly develop this new capability, nor explore its impact on our tactical operations. Joint STARS does not currently have IDM; *"JSTARS is getting IDM ability via a laptop plug-in within their jet. They intend to use this to pass modified 9-line info to* [F-16]*CJs and possible IDM equipped* [F-16]*CGs."* Maj Randall Vogel, 55th Wing Exercises and Plans Office, Offutt AFB, NE, interviewed by author via email, 7 March 2000. Further discussion on the Joint STARS and IDM is available from the website of the Federation of American Scientists. "Intelligence Resource Program," *Federation of American Scientists, n.p.: on-line, Internet, 20*

February 2000, available from http://www.fas.org/irp/program/collect/jstars.html. As of this writing, they have yet to exercise this new capability with USAF fighters.

[9] See Appendix E for additional examples of the model predicting successful targeting constellations. See Appendix F for examples of the TCT model predicting unsuccessful targeting constellations.

[10] The Aerospace Command and Control, Intelligence, Surveillance, Reconnaissance Center (AC2ISRC) at Langley, AFB; the All-Service Combat Identification Evaluation Team (ASCIET) at Eglin AFB, and the Joint Suppression of Enemy Air Defense (JSEAD) program at Nellis AFB to name only a few.

[11] Maj Jeff Lutes and Maj Joseph Harvey, AC2ISRC, Sensors and Platforms Division Airborne Reconnaissance Branch (C2RR), Langley AFB, VA, interviewed by author via email, 2-3 March 2000.

[12] According to a current test program entitled Multi-Platform Emitter Geolocation being conducted by the RC-135 Detachment 2. Maj Donald Finley. Detachment 2, 645 Materiel Squadron, Greenville, TX, interviewed by author via email, 7 March 2000.

Part 5

Conclusion

Sex, war, and walking on the moon—three things you just can't learn from a book; you gotta experience them yourself to truly understand.

—Captain William Danskine, 1999

On Beyond JFACC

a. Additional Research Requirements.

Throughout this paper I have used notional values for the accuracy and timeliness of sensors and the accuracy required for the shooters' weapons. Test and evaluation agencies, traditionally used for weapons and airframe testing, should conduct detailed tests to measure the exact values for each ISR asset.[1] Sensor data—such as the probability of an RJ detecting a SAM in mountainous versus flat terrain; the average time it takes for an EP-3E to identify a MiG-29 and disseminate it; or the location precision of an RC-12 Guardrail—could all be incorporated into a computer simulation. Many system program offices of each platform have this type of data available; it merely needs to be collected. With this simulation, Numbered Air Force/Air Expeditionary Force (NAF/AEF) planners could calculate the most timely and accurate targeting constellations using critical path analysis. Yet this is only half the battle.

b. Training and Acquisition.

A technological solution cannot overcome a lack of skill.[2] Once the NAF/AEF planners have identified the targeting constellations required for their theater, they must ensure crews are trained. They should make every effort to develop the TTPs necessary to make the targeting constellations work, using exercise employment to fine tune these TTPs. If the TCT matrix identifies a targeting constellation that includes Joint STARS, UAVs, and A-10s for close air support, then these platforms should fly sorties together against large ground forces to develop the appropriate TTPs. Occasionally, Nellis or Tyndall evaluators will identify shortfalls in targeting constellations, such as ISR assets unable to disseminate their information to each other or to the shooter. Once identified, these shortfalls may be addressed by NAF/AEF planners prior to arrival in theater. In the case of the RC-12, the sensor is currently unable to communicate directly with in-theater ISR sensors or shooters. If theater planners are expecting to use such an asset, they must gain connectivity.

c. Application to Ground/Naval Engagements.

This model should not be limited to USAF assets, or even air assets. The model equally applies to land, naval, and space target engagements, and may highlight cross-service sensor-to-shooter constellations (such as AEGIS and fighters, or Joint STARS and the Army's multiple launch rocket system). Future discussion of the TCT model should incorporate these assets as well.

Each of these areas—further research, training and acquisition, and incorporating land and sea targets—are additional opportunities to use the TCT model to systematically examine how we integrate our platforms to engage targets. The concept of critical path analysis to identify the optimum targeting constellation lends itself to computer simulation. We merely need to

consolidate the data from individual assets to make the simulation a reality. In this way can we be proactive and avoid relying on the ad hoc creation of targeting constellations during late-night mission planning sessions among haggard warfighters.

Parting BVR Shot

The TCT model provides the JFACC a method for quickly optimizing sensor and shooter relationships, while filling the gap that exists between the tactical 3-1 TTPs and Air Force operational doctrine. It demonstrates the functions necessary for time-critical targeting, and evaluates assets that may fulfill each function. The model demonstrates which combinations of assets, out of the universe of sensors and shooters, best create timely and accurate targeting constellations—those combinations of systems that optimize time-critical targeting.

Using this model, a theater's JFACC may optimize those assets available to him. The JFACC also may use this model to recognize degradation, and develop workarounds, when certain systems become unavailable. The JFACC may knowledgeably adjust the precision factors (either his ROE or his weapons) to adapt to whatever assets he has on hand. By applying this model, planners may proactively use the proposed computer model to create new targeting constellations and establish new requirements. Once identified, planners should allow these new teams to practice their sensor-to-sensor-to-shooter interaction. Acquisition personnel can then identify shortfalls in targeting constellations and direct programs for correcting these shortfalls.

Academic study only goes so far. Once a sensor-to-sensor-to-shooter relationship is developed on paper, it must be put into practice. Assets must work together to prove or disprove the concept; aircrews must learn how to plan and employ within these new constellations. Only in actual operation do we discover the true obstacles to interaction. Only with practice can we overcome these obstacles, and firmly establish a true time-critical targeting process incorporating

our tactics, techniques, and procedures. Perhaps then we will attain the results Lt Gen Caemmerer hoped to achieve with his era's technology, developing our own "electric telegraph."

Notes

[1] Organizations such as All-Service Combat Identification Evaluation Team (ASCIET) and Joint Suppression of Enemy Air Defenses (JSEAD) are conducting exercises to measure similar data. ASCIET's charter includes concentrating on tactics, techniques and procedures that will minimize the possibility of fratricide. JSEAD is attempting to improve the integration of ISR assets in the SEAD mission. JSEAD collected much of the data required for the computer simulation, however they have yet to release the data to the Air Force at large (and many have raised questions as to the efficacy of the data collection). Over the last two years, neither exercise has been able to accurately assess the abilities of all ISR assets; real-world crises (DESERT FOX and ALLIED FORCE) have prevented many ISR assets from participating. From the author's experience as a Rivet Joint exercise planner.

[2] As aptly argued in Stephen Biddle, Wade P. Hinkle, and Michael P. Fischerkeller, "Skill and Technology in Modern Warfare," *Joint Forces Quarterly*, Summer 1999, 18-27.

Appendix A

Why Multiple Systems?

In the modern era, few weapon systems have the ability to engage their targets on their own.[1] The F-105/F-4G Wild Weasel is one of a few examples of a weapon system able to independently engage targets.[2] During the Vietnam War, Wild Weasel crews had the ability to find and engage surface-to-air missile (SAM) sites using their onboard detection equipment and weapons, with minimum assistance from off-board sensors or other airmen.[3] But circumstances today are driving military tactics in new directions. Fiscal restraints and the problems of technological stove-piping are limiting the number of specialty assets we can develop. Single-mission platforms are too expensive to support. Multiple weapon systems interacting with other systems are now the rule. In the counterair role, an F-15C's ability to detect enemy aircraft is enhanced by the long-range capabilities of the E-3 AWACS radar.[4] The same symbiotic relationship is seen in the F-16CJ interaction with the RC-135 Rivet Joint.[5] The RC-135 has a much greater field of view (FOV) and much longer time on station capability than the F-16CJ, and is able to build an enemy order of battle and pass it to the fighter as it arrives on station.[6]

Lt. Col. Brungess highlights in "Setting the Context: SEAD and Joint War fighting in an Uncertain World" this transition toward multiple weapon system operations in US Air Force Suppression of Enemy Air Defenses (SEAD) and Electronic Combat (EC). "*The EC triad* [originally consisting of the F-4G Wild Weasel, the EF-111 Raven, and EC-130H Compass Call]

has developed into a constellation and has grown to include the airborne warning and control system (AWACS) E-3, the EC-130E airborne command and control center (ABCCC), and the RC/EC-135 (electronic surveillance aircraft that can identify and locate specific emitters)..."[7] He views single-mission weapon systems as fiscally untenable, and this factor outweighs mission effectiveness. "*While undeniably better suited for the SEAD environment than any other single aircraft in the world, the F-4G is also a very specific, single-mission weapon systems. Considering that it is very expensive to operate and performs only a single mission, the F-4G appears less and less likely to survive in a fiscal and strategic environment that stresses economy and general capability.*"[8] The demise of the F-4G program demonstrates how single-mission, single-sensor systems that can operate independently of outside assistance, regardless of capability, are now obsolete in the USAF inventory.

There is another reason, besides financial restraints, that single-sensor systems are obsolete. Independent programs often lead to independent reporting and computer systems with incompatible message formats. Major James Marshall, in his detailed paper "Near-Real-Time Intelligence On The Battlefield" believes past development of single-sensor systems led to an inability for systems to pass each other battlespace information.[9] Our doctrine depends upon exchange of multi-spectral information between sensors. Allowing multiple sensors to "talk" with each other (sometimes called "cross-cueing") creates a synergy that takes advantage of system strengths, and overcomes system weaknesses. Marshall gives an example: "*SIGINT systems generally can provide timely warning information, but initially can provide only coarse positional information until numerous intercepts have been made. Imagery systems provide detailed positional information, but have difficulty surveying large areas. Providing rough positional information from SIGINT sources to IMINT systems greatly enhances the speed and*

accuracy of the overall intelligence system as well as providing a measure of confidence against deception."[10] This fused SIGINT and IMINT information can then be passed to an orbiting shooter. An F-15E with joint direct attack munitions (JDAM), for example, now has targetable information precise enough for employing the weapon. Martin Libicki provides other examples of system interaction in his book "What is Information Warfare?"[11] The bottom line is that many variables are leading us toward multi-system constellations and away from single-system platforms. Resource limitations and the risk of stove-piped technology are forcing us toward integration of multiple, multi-role, platforms tailored to fit the given military situation.

Notes

[1] AFP 51-45 gives a quite clear description of how the SEAD mission is progressing from single aircraft operations toward a constellation of sensors and weapons systems. "*Wild Weasel aircraft are basically self-sufficient because they can accomplish their mission with onboard equipment and ordnance. However, other systems being developed are considerably more complex. They require both ground-based and airborne equipment. These systems provide the tactical Air Force with an all-weather, day/night, near-real-time integrated target location and strike capability. The specialized equipment aboard highly instrumented aircraft detects electronic emissions from enemy air defense radars and relays that data to a ground-based processing and control center. The center analyzes the data and correlates it with inputs from other aircraft to identify and pinpoint the location of enemy radars. This processed target information is then provided to tactical units for both target assignment and improved command and control procedures. This system also has the capability to attack nonemitting targets that have been precisely located through other means such as photogrammetric targeting techniques.*" AFP 51-45, *Electronic Combat Principles*, 15 September 1987, 101. This is an accurate, though somewhat dated (circa 1987), prediction of how SEAD operates today. With advances in voice and data links, however, much of the targeting coordination takes place directly between aircraft, and does not involve coordination through a "*ground-based processing and control center.*"

[2] Regarding the F-4G Wild Weasel: "*This self-contained system uses the APR-38 wideband receiver in conjunction with a radar bombing and navigation system. It is capable of delivering a wide variety of ordnance including ARMs* [antiradiation missiles], *EO* [electro-optic] *weapons, and conventional bombs. The Wild Weasel's primary mission is to locate and destroy or suppress hostile threat emitters.*" AFP 51-45, 100.

[3] "*The F-4G Wild Weasel is the only aircraft in DOD that was designed to identify, locate, and destroy specific radar emitters by mating an extremely sophisticated radar homing and warning receiver to an equally sophisticated antiradiation missile.*" Brungess, 107.

[4] "*The counterair process is not just airplanes—it's a system*" according to Maj James M. Holmes, *The Counterair Companion: A Short Guide to Air Superiority for Joint Force Commanders* (MAFB, AL: AU Press, April 1995), 19, when referencing R. A. Mason, *Airpower: An Overview of Roles* (London: Brassey's, 1987), 18; and J. R. Walker, *Air Superiority Operations* London: Brassey's, 1989, 1, 136. Additionally, AFP 51-45 claims technology limits the ability of a single aircraft to conduct the entire counterair targeting process. "*Technology has not yet been able to fit into the confines of a high-speed airframe a radar system which is capable of the complete task of target location and interception at extended ranges. To discuss the airborne interceptor as a weapon systems, it is necessary to start with the radars which control the intercept.*" AFP 51-45, 104. AFP 51-45 then goes on to describe how the notional fighter receives initial command and control to the intercept from either ground-based or airborne assets with long-range radars.

[5] Air Vice-Marshal Tony Mason, *Brassey's Air Power: The Aerospace Revolution* (London: Brassey's, 1998), 68.

[6] Ibid., 87.

[7] Brungess, 104.

[8] Brungess, 127.

[9] Marshall, 50.

[10] Ibid., 50-51.

[11] "*Platforms that host operator, sensor, and weapon together will give way to distributed systems in which each element is separate but linked electronically. The local decision loop of industrial age warfare (e.g., a tank gunner uses infrared sights to detect a target and fire an accurate round) will yield to global loops (e.g., a target is detected through a fusion of sensor readings, the operator fires a remotely piloted missile to a calculated location).*" Martin C. Libicki, *What is Information Warfare?* Center for Advanced Concepts and Technology, Institute for National Strategic Studies (Washington, DC: National Defense University, 1995), 20.

Appendix B

Decision (OODA) Loop

It is essential in modern warfare to dominate the battlespace with information superiority, to gain what Johnson and Libicki call "Dominant Battlespace Knowledge" or DBK. "*The desire to take advantage of* [the] *opportunity provided by DBK drives us to minimizing the decision and execution cycle—going from seeing a target to destroying one*."[1] By obtaining more information about the battlespace, by discerning our opponent's actions and intentions and then acting before he can react, we maintain the initiative in battle. But "knowing more" is not enough; we must also get this information to the warfighter. Johnson and Libicki believe "*to minimize the decision/execution cycle, the path from sensor to the shooter needs to be minimized—if possible, to go directly from the sensor to the shooter*"[2] with real-time information into the cockpit (RTIC). RTIC allows decisions about mission execution to be made at the lowest possible level in the shortest possible time—an OODA cycle unprecedented in aerial warfare.[3] But what is this decision cycle, this OODA loop, Johnson and Libicki are referencing?

The decision loop (also known as the "OODA loop") is a model for the command and control process developed by Col John R. Boyd. It is meant to represent how a "system" (to include, in our discussion, all sensors and shooters making up a targeting constellation) can adapt to a changing environment. Adapting to a changing environment, or enemy activity, while attempting to degrade the adversary's ability to adapt, is instrumental to successful military

operations. The object, as Maj. Fadok sees it, is to minimize one's OODA loop; "*one must operate at a faster tempo or rhythm than one's adversaries*" to "*render the enemy powerless by denying him the time to cope mentally with the rapidly unfolding—and naturally uncertain—circumstances of war.*"[4]

There are four phases to the decision loop: Observation, Orientation, Decision and Action. It is within the first and second phases, Observation and Orientation, that targeting information is passed between sensors, and from sensor to shooter. "*Speeding up the OODA process depends upon the speed of Detection, Location and Identification, as well as the communication process between the various sensors and the C2 node. The accuracy of the OODA process depends upon the Location process (effectiveness of the engagement, does the munition go to the wrong place) and Identification process (problems with fratricide, collateral damage, etc.) as well.*"[5]

Within each of the four phase, there are assets that specialize in performing the functions of that phase. I will limit my examples to USAF assets, doctrine and tactics, however this C2 model applies to other services and assets as well.

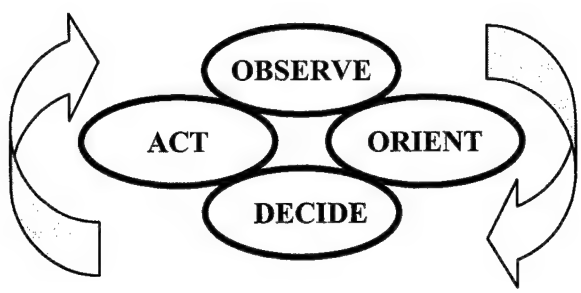

Figure 18. The OODA Loop

The decision cycle is continuous, however we traditionally begin with the Observe Phase.

OBSERVE

> Observations describe the gathering of data regarding the status of enemy and friendly forces, the battlefield, or other significant areas of interest. Before battle is joined, it is needed for the formulation of plans; once fighting begins, observation is needed to detect the new reality that results from the initial battle and enemy reactions. It may also include surveillance by a variety of sensors, subordinated units, or individuals and has often included direct observation of the battle by the commander. Observation is a necessary element of adaptation because it is required to detect changed or unanticipated realities of the battlefield.[6]

To "observe" the threat environment, USAF aircraft must have sensors capable of detecting signs of the enemy. Those aircraft best suited for this role include those who "observe" the picture, the raw data. Examples include active sensors, such as the E-3 AWACS and E-8 Joint STARS aircraft, who emit radar to detect enemy COIs. Passive sensors, such as the RC-135 Rivet Joint (and other SIGINT assets), also detect COIs by collecting electronic or communications emissions from enemy systems.

ORIENT

> Orientation describes the translation of data into useful information; its product is the organization's perception of reality. Boyd considered orientation the most important part of the OODA loop: "*Orientation is the schwerpunkt. It shapes the way we interact with the environment—hence orientation shapes the way we observe, the way we decide, the way we act.*" Analysis and synthesis of an organization's observations should contribute to the formulation of insights into difficulties experienced on the battlefield. With the formulation of these vital insights, the need to adapt can be perceived. Orientation is a necessary element of adaptations and must result in the perception that a need or opportunity exists to improve performance. Adaptation can be expected as a response to the challenges of war, but it may also spring from the realizations that an opportunity to achieve enhanced results exists.[7]

The critical functions of the Orient Phase are performed by those assets capable of assembling large amounts of combat information from multiple sources and correlating it into a

useable view of the battlespace. These assets discern the valuable intelligence of enemy activity, and translate the battlespace picture into targetable information. They then disseminate this targeting information to the shooters. AWACS currently performs this function for the counterair role. In the future, Joint STARS may perform this role in the close air support and interdiction (counterland) missions, and the Rivet Joint may perform this role for SEAD. Several programs (chiefly the Office of the Secretary of Defense's JSEAD program, located at Nellis AFB, NV) have examined the possibility of performing this function in the AOC, taking advantage of modern voice and data link capabilities.

DECIDE

> Decision describes the formulation of courses of action (COA) and their selection. At this point alternative solutions are evaluated and optimal solutions selected. The formulation of new solutions is contingent on the participant's ability to imagine and articulate new options. It is the role of the organization to cultivate, encourage, and recognize valuable solutions. It then falls on the commander to decide whether or not to implement new solutions, or to delegate sufficient freedom of action to make such decisions at lower levels. The cultivation of ideas and the decisions to implement them are necessary for adaptations. Intuition, creativity, and imagination are all individual characteristics of the commander, his staff, and subordinates that can lead to the initiation of an innovation. For a proposed innovation to have an effect it must be implemented, which hinges on the decision of someone in a position of authority.[8]

The Decide Phase is command and control. These functions are performed by those decision makers who implement action based on the generated battlespace picture. They establish target priorities (informing sensors in the Observe Phase what they should look for), designate targets based upon the battlespace picture (generated in the Orient Phase), interpret the rules of engagement for each scenario, commit forces onto those targets designated as hostile, and give permission to engage (in the Act Phase). Typically, this function resides in the AOC,

but should also be spelled out in theater ROE. Occasionally, this function resides on the airborne C2 (perhaps as an Air Command Element, or ACE).

ACT

> Action describes the implementation of plans (i.e., combat operations), although it may also entail changes to organizations, procedures, or equipment. Although it may be easy to concentrate attention to only the actions of one's military forces and the effects of their activities on the enemy, there is another important dimension of action. Every decision must be transmitted through the organization in order for it to be implemented. Planning, coordination, training, and execution are all part of the process. It is here—when actions are implemented—that innovations affect the system and should be graded for effectiveness and timeliness. It should be noted, however, that innovations cannot be graded without further observation and orientation.[9]

The fourth phase is to Act. The actors for this phase are the shooters: any system that can put missiles, bombs, bullets, or jamming on target.

Notes

[1] Stuart E. Johnson and Martin C. Libicki, eds., *Dominant Battlespace Knowledge.* Center for Advanced Concepts and Technology, Institute for National Strategic Studies (Washington, DC: National Defense University, 1996), 82.

[2] Ibid.

[3] "*Real-time information into the cockpit offers an OODA cycle unprecedented in aerial warfare*." Chapman, 55.

[4] Maj David S. Fadok, *John Boyd and John Warder: Air Power's Quest for Strategic Paralysis* MAFB, AL: AU Press, 1995. Reprinted in Phillip S. Meilinger, ed., *The Paths of Heaven: The Evolution of Airpower Theory* (MAFB, AL: AU Press, 1997), 364.

[5] Ibid.

[6] From the description of Boyd's decision loop in Lt Col William F. Andrews, *Airpower Against An Army (*MAFB, AL: AU Press, 1998), 6-7.

[7] Ibid., 7.

[8] Ibid., 8.

[9] Ibid., 9.

Appendix C

The Combat Identification Matrix

We may apply an existing targeting model as a foundation for time-critical targeting, namely the combat identification (CID) matrix (see Figure 19). Rules of engagement (ROE)[1] have long been a central concept of interaction between theater C2 and shooters when engaging enemy aircraft.[2] The CID matrix is regularly employed by the E-3 AWACS and fighters in the counterair role as a part of a theater's (ROE).[3] A contact of interest (COI) is detected by AWACS and a track is generated to indicate the location of the COI. The crew then use various on- and off-board methods to identify the track, ensuring they have both "positive enemy" and "lack of friendly" indications.[4] The track is then identified as a "bandit." The AWACS crew then refer to theater ROE which should contain definitions of hostile activity which would define hostile targets to be engaged.[5] If the bandit's behavior meets the ROE criteria, the track will be declared "hostile" and may be engaged. The track becomes a target. The necessary information, namely location and identification, is passed to counterair aircraft with the clearance to engage the target.

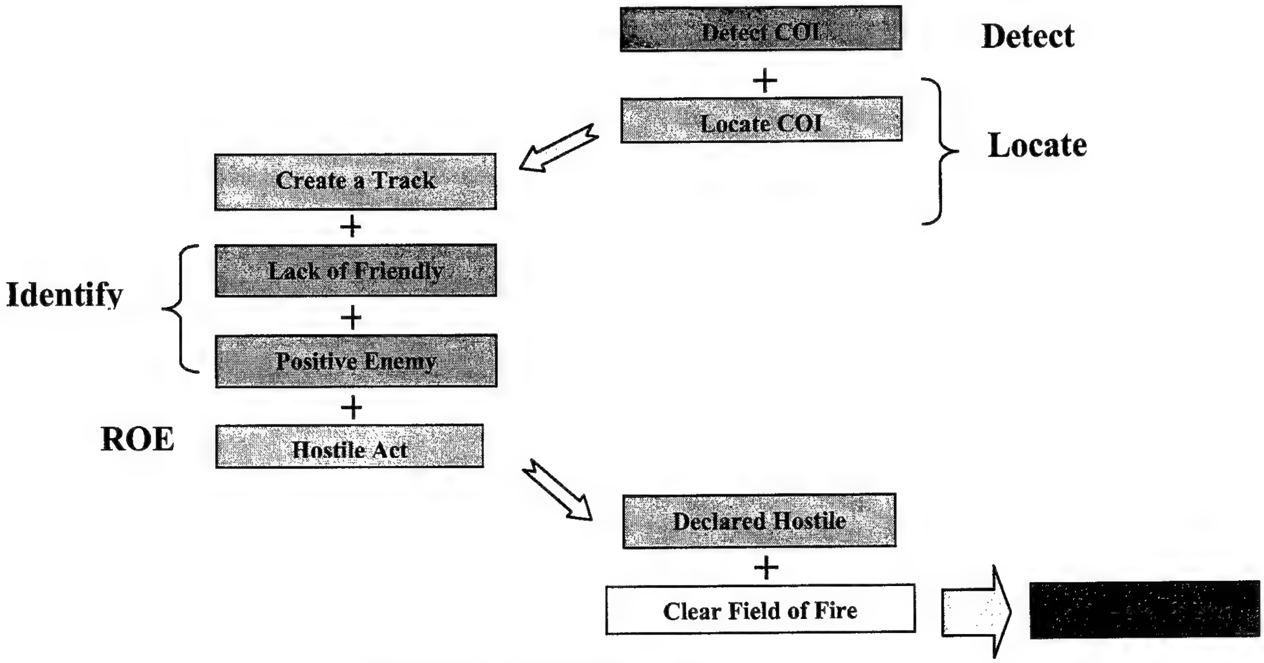

Figure 19. The CID Matrix

This CID matrix can be expanded to include forms of targeting beyond air-to-air engagements. The matrix demonstrates the process of how a contact is detected, located and identified to produce a target, and indicates how command and control use rules of engagement to determine if the target shall be engaged. The CID matrix needs to be expanded, however, to address how various assets might fulfill each function of the targeting process.

Notes

[1] Rules of engagement (ROE) are "*directives issued by competent military authority which delineate the circumstances and limitations under which United States forces initiate and/or continue combat engagements with other forces encountered.*" Joint Publication 1–02, n.p.

[2] "*Accurate and timely identification (ID) enhances real-time tactical decisions and optimizes weapons employment, allowing timely engagement of enemy aircraft and missiles, conserving resources, and reducing risk to friendly forces.*" AFDD 2-1.1, *Counterair Operations*, 6 May 1998, 17-18.

[3] Reference Air Force Tactics, Techniques, and Procedures Manual 3-1, Volume 15, *E-3 AWACS Concept of Operations* (Secret) for a classified discussion of the E-3 AWACS Combat Identification Matrix. Information extracted is unclassified.

[4] "*The optimum employment of defensive weapon systems depends on early separation of friend from foe. Positive identification of hostiles allows for maximum beyond-visual-range engagement and minimizes fratricide. Just as importantly, self-defense ROE related to air-to-surface and surface-to-surface threats for both OCA (particularly for time-sensitive targets) and DCA situations must be developed and understood.*" AFDD 2-1.1, 1998, 15-16.

[5] "*The JFC is responsible for developing and implementing ROE unless it is established by higher authority or existing plans.*" Ibid., 16.

Appendix D

Existing Targeting Constellations

To be useful to theater operational planners, this time-critical targeting model must apply to many diverse target engagement scenarios.

Scenario 1. Engaging a Mobile Ground Target. (Figure 20). It is difficult to preplan interdiction ground targets in the fluid environment expected during the initial Halt Phase of a conflict. Time-critical targets, such as mobile SCUD missile launchers, may make it impossible to preplan strike coordinates. Therefore, bomb-droppers of the next conflict will likely receive their targets while airborne. This could occur with close air support, "flex-targeting" interdiction missions, or SCUD-hunting.

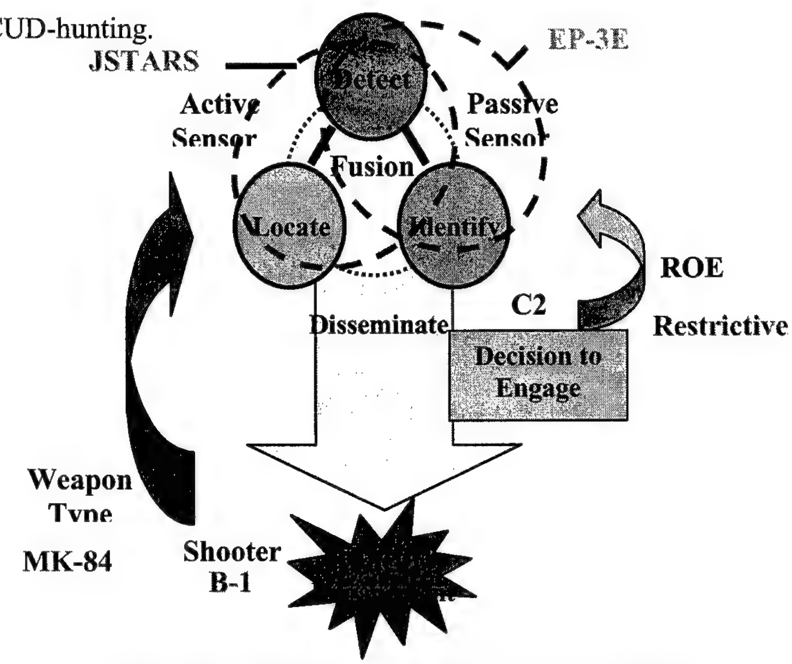

Figure 20. Engaging a Mobile Ground Target.

Scenario 2. Shooting a HARM. (Figure 21). In this example, a SIGINT aircraft detects a radar, and identifies it as an enemy SAM system. The radar is located within enemy territory, well away from any possible locations of neighboring countries who might have the same radar system. The location, although not sufficient for precision munitions, is accurate enough to provide targeting information to the HARM. The SIGINT aircraft determines that the SAM is active while friendly aircraft are within the Weapons Engagement Zone (WEZ) of the threat. According to the ROE (SPINS), this threat is then declared "hostile". The threat information is passed to a HARM-shooter, and engaged.

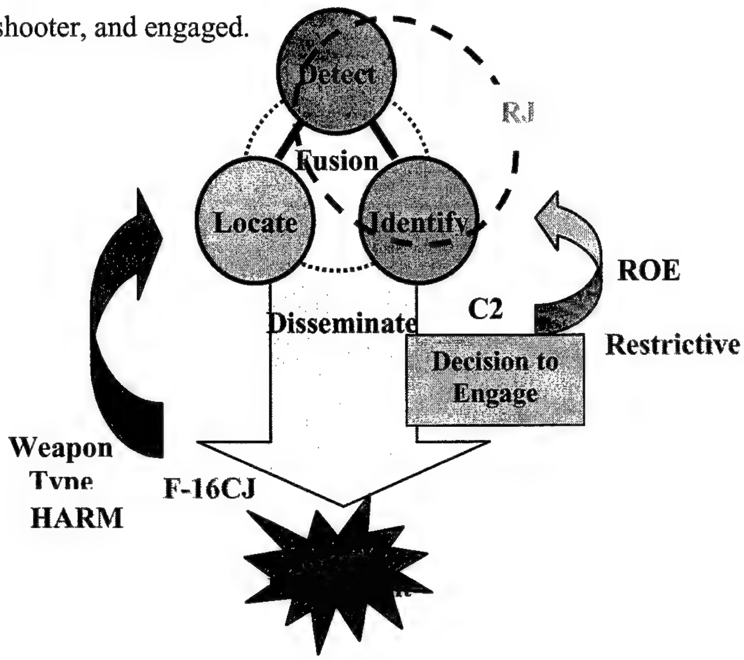

Figure 21. Shooting a HARM.

In this example, the passive sensor SIGINT aircraft performs all three initial functions of the TCT process for target designation, and disseminates the target information to the shooter (the F-16CJ). The weapon system (the HARM) does not require a precise location; the location provided by the passive sensor is precise enough to engage the target. The ROE is very restrictive to avoid fratricide of friendly forces, therefore proper identification is required. If the political or military situation allows, and accurate identification assets are not available, the ROE

may be loosened. Shooters could operate independently, without passive sensor support. Shooters could then engage with questionable identification of the target (for instance, F-16CJs could launch HARMs based on their onboard sensors without confirmation by other sensors). This, obviously, increases the risk of shooting a HARM toward something unintended.

Scenario 3. Jamming a Communications Frequency. (See Figure 22). A SIGINT aircraft detects communications, and identifies it as enemy GCI communications. That aircraft is able to roughly determine the location, verifying that it is emanating from enemy territory. The location is not precise enough to engage targets with precision weapons, but is precise enough to provide targeting information to a jammer. The ROE are then consulted (in the form of the SPINS and joint restricted frequency list). If the "threat" (the enemy communications) is declared hostile, the threat is "targeted" by jammers such as the Compass Call.

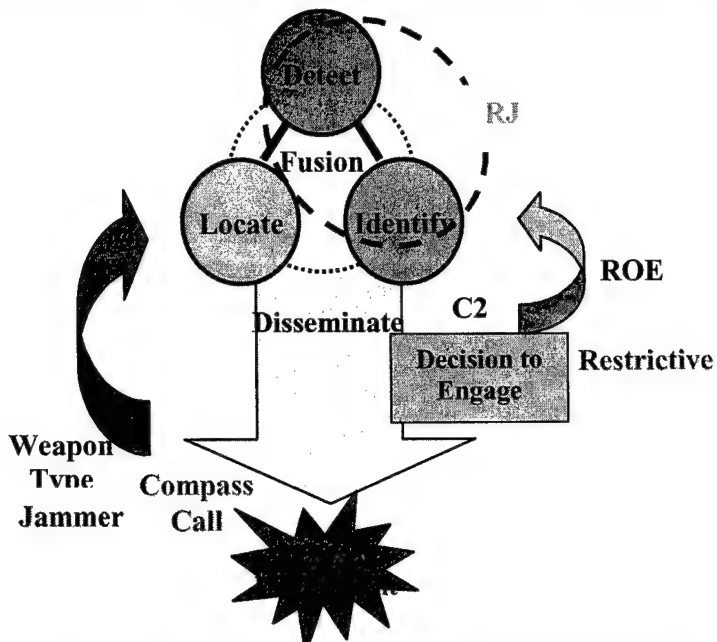

Figure 22. Jamming a Communications Frequency.

In this example, the passive sensor SIGINT aircraft performs all three initial functions of the TCT process for target designation, and disseminates the target information to the shooter (Compass Call). The shooter (the communications jammer) does not require location precision;

the location provided by the passive sensor is precise enough to engage the target. ROE for jamming a communication signal is restrictive, thus accurate identification is crucial.

Scenario 4. Engaging an Aircraft. (See Figure 23). AWACS detects a COI, and locates it in enemy territory, thus creating a track. A SIGINT aircraft detects enemy aircraft emissions. These two bits of information are correlated (fused) to designate the track as a threat (bandit). Although the location precision of the threat may not be precise at a great distance, it is sufficient for a fighter to acquire the threat with its own radar. If the bandit then performs a hostile act (as set forth in the ROE) it is declared a hostile. This target information is passed to the fighters to engage. If ROE are permissive, AWACS and shooter may not need precise identification (i.e., they may not need to differentiate between "Iraqi aircraft" and "Iraqi MiG-29") and thus not need precise identification. If the ROE are very restrictive, and no passive sensor is able to identify the COI, the pilot must then resort to the time-honored tradition of visual identification.[1]

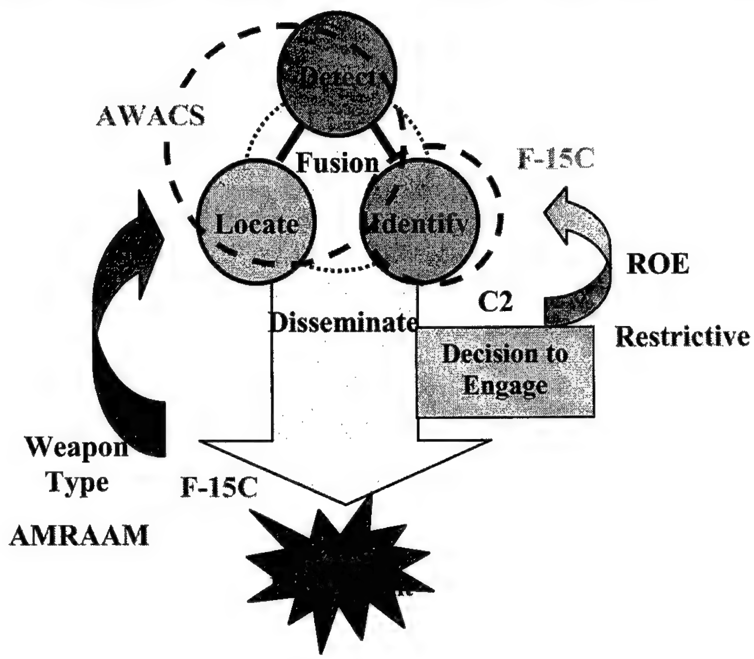

Figure 23. Engaging an Aircraft.

[1] This method has not always proved accurate, and it is certainly more dangerous for the pilot doing the visual identification.

Appendix E

Predicting Targeting Constellations That Will Work

RJ/F-15E or B-1. The Rivet Joint can also be useful working with either the F-15E or B-1 bomber in an air-to-ground role (Figures 24 and 25). Both the F-15E and B-1 have very precise air-to-ground radar capabilities, but with limited FOVs. A passive sensor, by passing identified targets with rough locations, would allow the shooters to acquire time-critical targets and subsequently refine the location sufficiently to engage. In both cases, the Rivet Joint's broader field of view to detect the COI, and its ability to identify the target, enhances the shooter's ability to employ weapons on target.

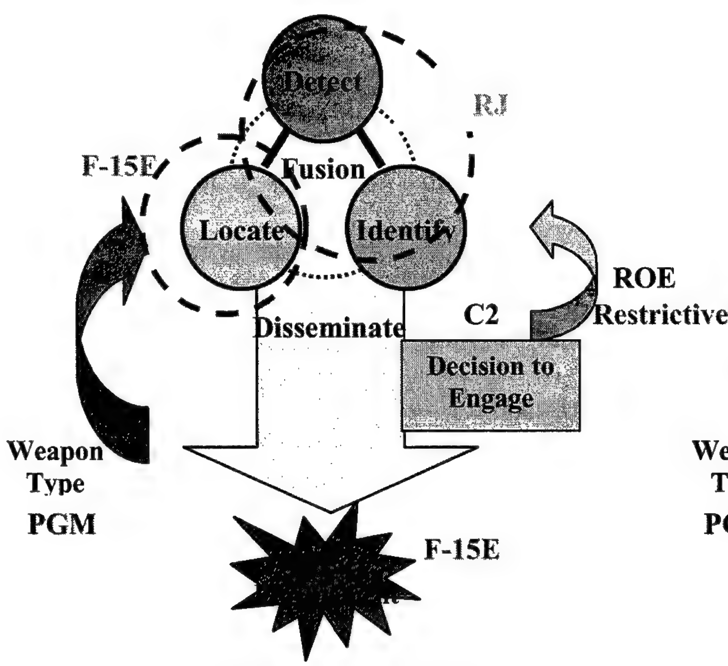

Figure 24. RJ/F-15E.

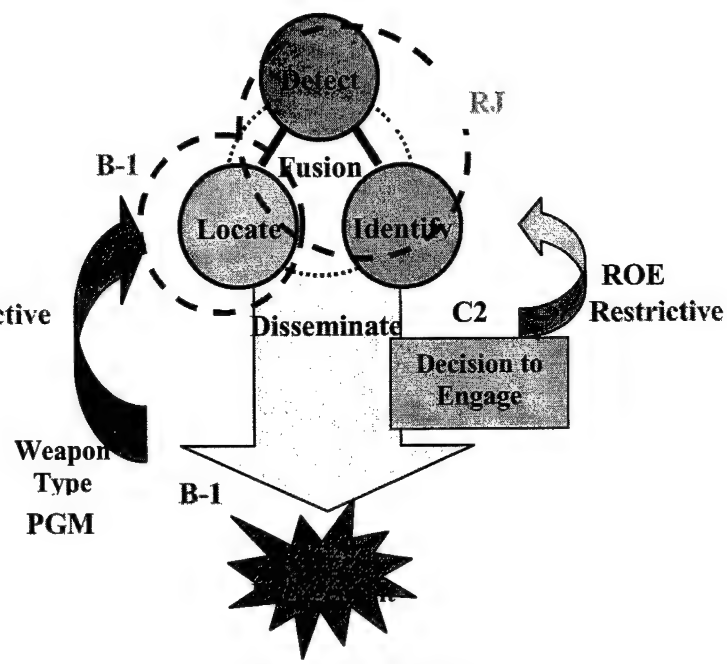

Figure 25. RJ/B-1.

Joint STARS/Cobra Ball. (Figure 26). A new mission demanding attention from mission planners is that of theater missile defense (TMD).[1] One targeting constellation that might be successful in the TMD role is the RC-135S Cobra Ball and Joint STARS. Using the Theater Airborne Warning System,[2] Cobra Ball can detect launches of theater ballistic missiles and, by calculating the trajectory of the missile, determine its impact and launch points.[3] Passing the detection and identification of a missile launch, along with a rough location, could cue the Joint STARS and allow commanders to designate detected vehicles in the vicinity of the launch as targets. A B-1 or F-15E could then be vectored in to destroy the launcher. On the other side of the missile flight profile, Cobra Ball information could be passed to a PATRIOT or AEGIS system to engage the incoming missile with defensive weapons. In both cases, the weapon to be used demands a location precision more than Cobra Ball is capable of providing. Yet this aircraft could provide the detection, identification, and initial location information to other systems with more precise location capability.

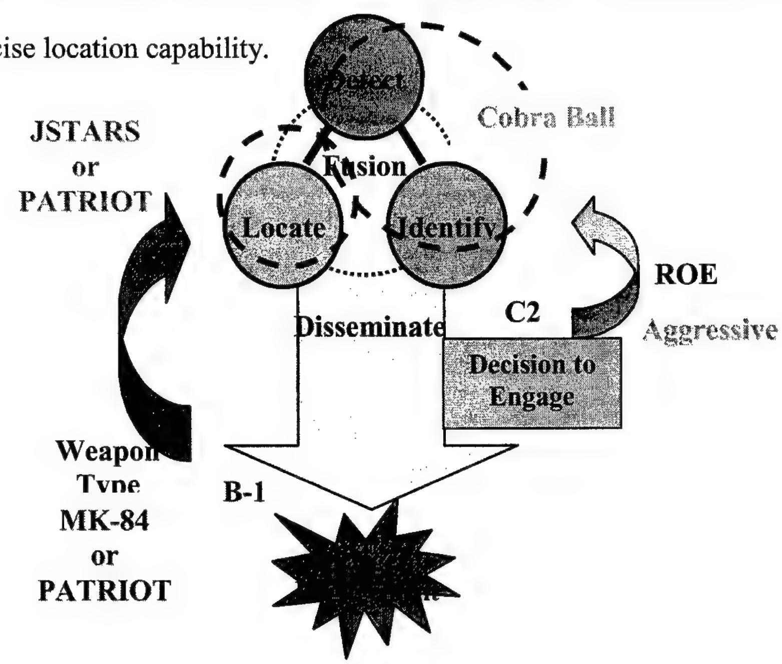

Figure 26. Joint STARS/Cobra Ball.

Joint STARS/RJ, UAV, or Acoustics. (Figures 27, 28 and 29). If identification is the shortfall of Joint STARS, then this can be balanced by a passive sensor, such as an RJ, for identification. But it could also be tied to a shooter with an accurate ID capability (the F-16CJ) or a UAV, with imagery identification capability. The Joint STARS could detect and locate COIs and direct UAVs into the area for electro-optical identification of the COIs. Once identified as a viable target, Joint STARS could direct shooters to engage. Future developments of acoustic sensors could also fulfill this identify function. Such sensors could be placed along key enemy lines of communication. When COIs are detected passing these sensors, Joint STARS could combine its detection and location (especially tracking) information with the identification provided by these sensors, and could then designate the COIs as viable targets.

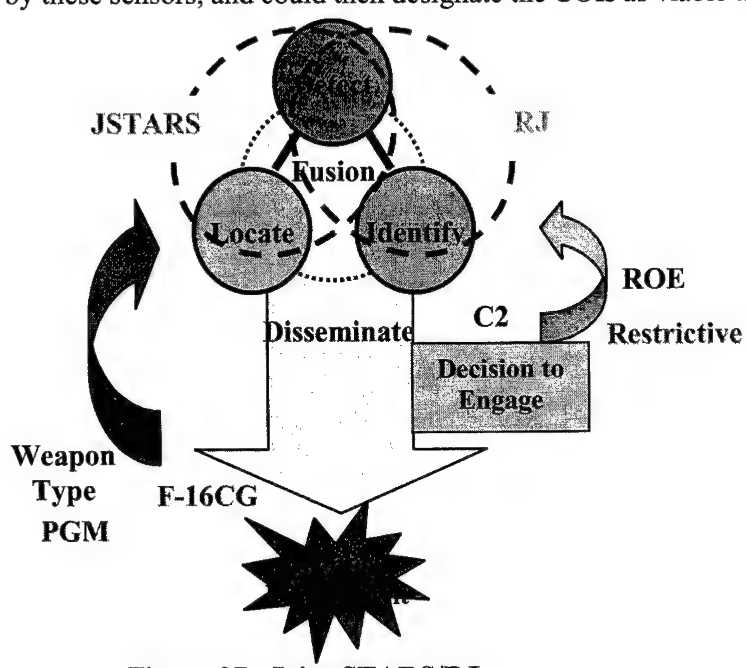

Figure 27. Joint STARS/RJ.

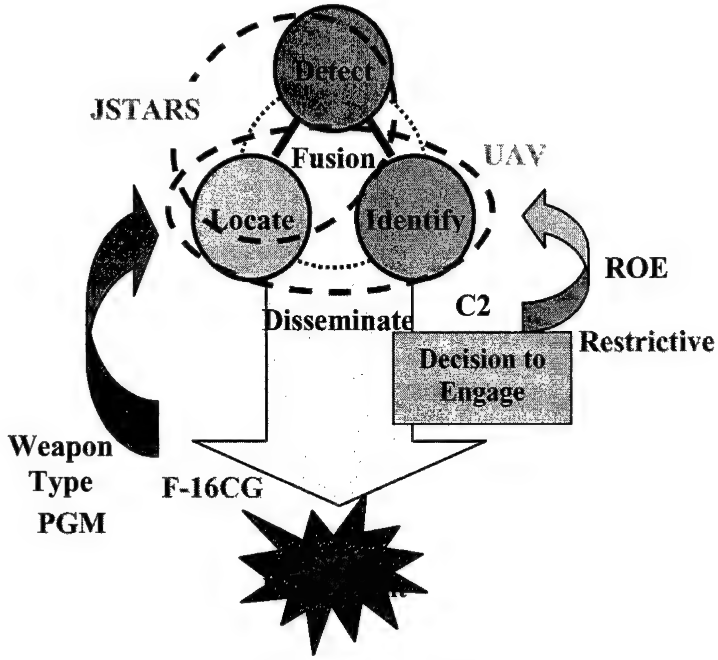

Figure 28. Joint STARS/UAV.

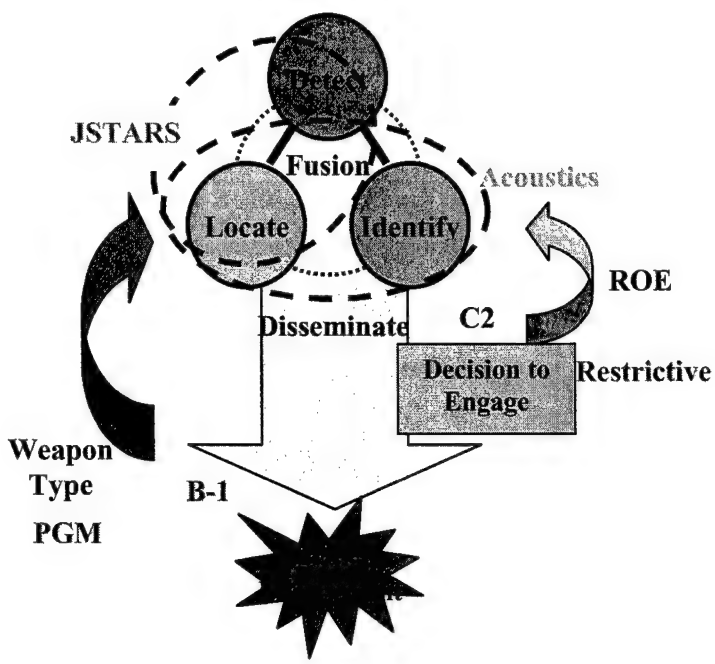

Figure 29. Joint STARS/Acoustics.

AWACS/F-16CJ. (Figure 30). Although primarily used in the counterair role, the E-3 AWACS also has some detection, location and identification capability for surface-to-air threats. Detected SAM sites, along with rough location and identification information, could be passed to F-16CJs. These shooters, with a very capable system for location (and a weapon that does not require significant location precision) would then engage the SAM. The AWACS provides the initial detection function, with its wider FOV.

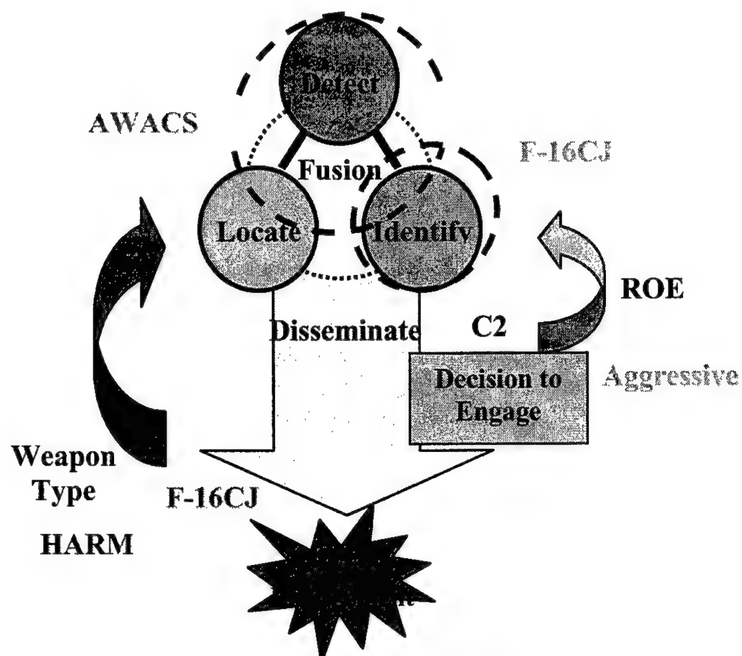

Figure 30. AWACS/F-16CJ.

Notes

[1] Especially following the destruction of an Army barracks in Dhahran during DESERT STORM. The Iraqi SCUD missile killed 28 soldiers, representing 36 percent of US Army deaths throughout the entire war. Air Vice-Marshal Tony Mason, *Brassey's Air Power: The Aerospace Revolution* (London: Brassey's, 1998), 74.

[2] The Theater Airborne Warning System (TAWS) uses a medium wave infrared camera to determine missile booster engine cutoff. This data is fused with data from the Defense Support Program to determine both launch and impact points, and disseminated via TIBS. TAWS is currently being installed on the Rivet Joint, but TTP for including this information into theater operations have not yet been developed. Maj Randall Vogel, 55th Wing Exercises and Plans

Office, Offutt AFB, NE, interviewed by author via email, 14 March 2000 (referencing the unclassified TAWS Executive Summary, Revision 3, November 1995).

[3] Robert S. Hopkins, III, *Boeing KC-135 Stratotanker: More Than Just a Tanker* (Leicester, UK: Midland Publishing Limited, 1997), 147-148. Also, Mason, *Brassey's Air Power: The Aerospace Revolution,* 75-76.

Appendix F

Predicting Targeting Constellations That Won't Work

Joint STARS. (Figure 31). The E-8C Joint STARS has a high resolution radar able to detect and locate ground COIs, specifically contacts that are moving.[1] However, other than using experience and "educated guesswork," the Joint STARS has a very limited ability to identify the tracks they produce (contrary to what many articles in the press claim[2]). Crews cannot accurately differentiate between a civilian automobile and an army truck. Interpreting the radar return is more art than science. Thus Joint STARS cannot independently designate targets to be engaged, unless the ROE is so aggressive (as in the kill boxes of DESERT STORM) that shooters are able to engage any COI located for them, whether identified or not. This is obviously a very difficult decision for the JFC, considering the highly-politicized conflicts expected in the foreseeable future. With terrorist groups, militias, and other non-military organizations mingled with a noncombatant local population, few western democracies will risk excessive collateral damage.

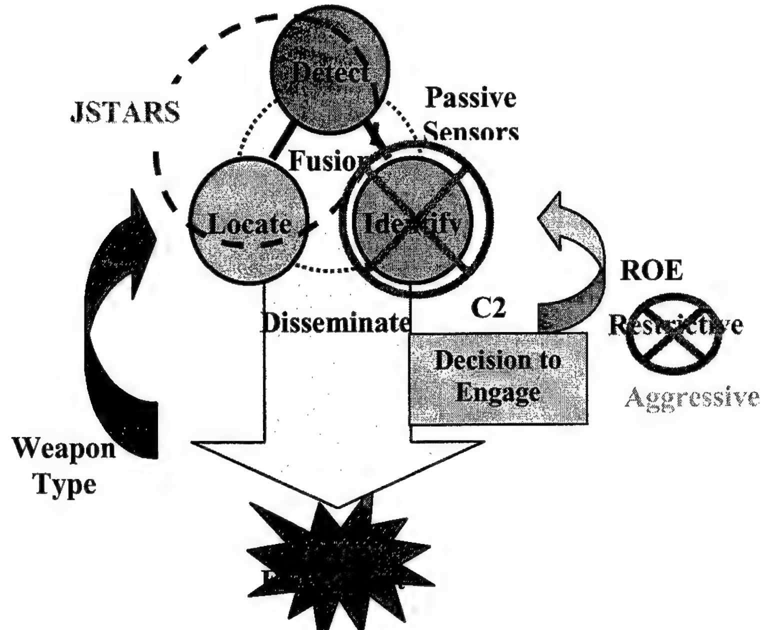

Figure 31. Joint STARS.

Joint STARS/B-52. (Figure 32). So, the Joint STARS system needs to work with a weapon system that can identify the COIs before they are designated as targets.[3] Recent training exercises have been conducted with the Joint STARS and B-52 bombers. Crews conducted several successful interoperability tests, and bombing runs were greatly enhanced by Joint STARS location information. And yet still, the identify function remains incomplete. Only in an aggressive ROE environment, with "anything north of the border dies" conditions, could this constellation be successful at targeting. This targeting constellation requires a passive sensor or visual identification (by the shooter or forward air controller) that can positively identify the COI to meet the ROE.

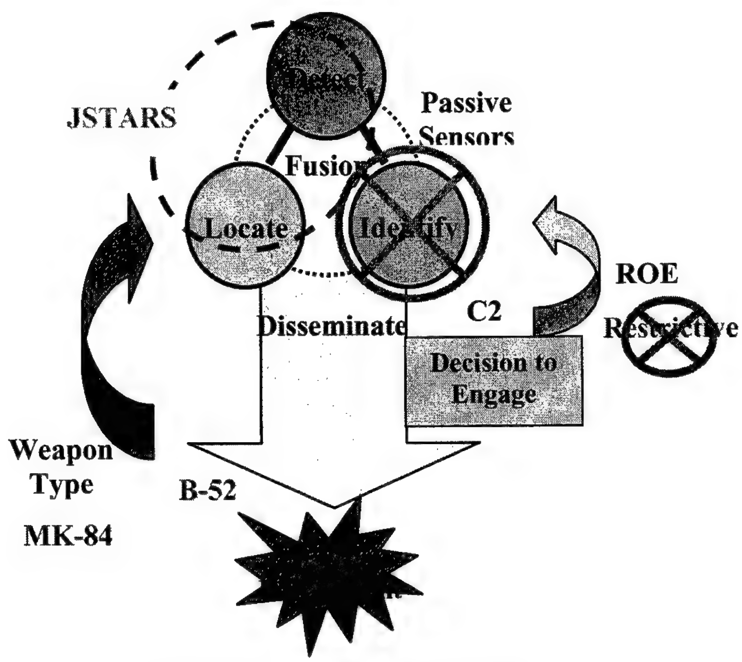

Figure 32. Joint STARS/B-52.

RJ/F-16CG. (Figure 33). Another targeting constellation that is unlikely to be successful is a passive sensor such as the Rivet Joint, and an aircraft employing precision weapons, such as the F-16CG. With current technology, passive sensors can detect and identify possible targets for air-to-ground shooters, but the location precision is not sufficient for GPS munitions. This is satisfactory for such weapons as the HARM, but unacceptable for precision munitions. To work around this situation, the shooter must receive the rough location from the passive sensor, and then acquire the target with its own sensors to refine the target location to employ weapons.

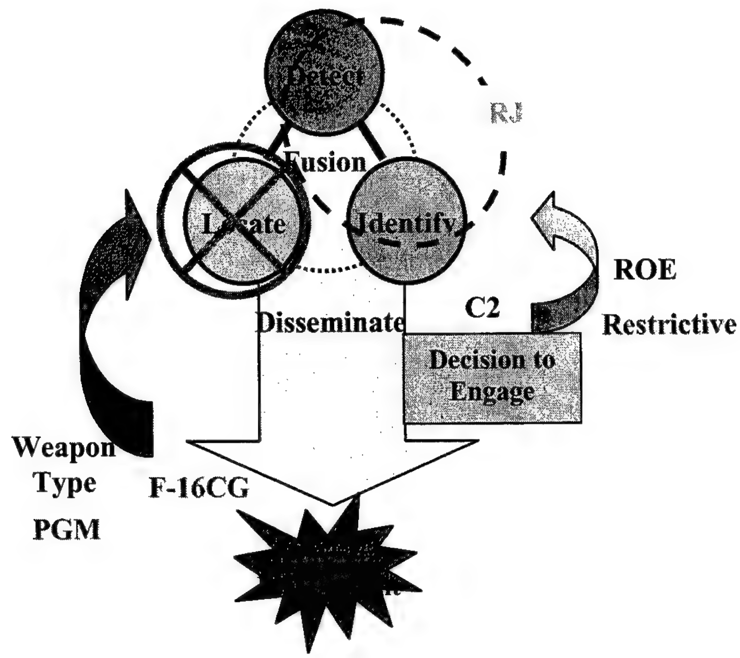

Figure 33. RJ/F-16CG.

Notes

[1] "*Joint STARS MTI* [Moving Track Indicator] *performance makes it possible to continuously detect, locate, track and classify in near real-time numerous vehicles moving throughout an extremely large field of view (over 40,000 square kilometers) from a significant stand-off distance.*" "*The quality of the radar's information and the manner in which it is displayed makes it easy for operators to quickly detect, accurately locate and precisely track vehicles.*" These are excerpts from *Joint STARS Airborne Ground Surveillance* pamphlet put out

by Northrop-Grumman at the Air Force Association 1997 Convention. Nowhere within this "advertisement" does it claim Joint STARS can identify what COIs it is detecting and tracking.

[2] "*Joint STARS can do far more sophisticated tasks than simply spotting moving targets. Earlier, for example, the aircraft's MTI picked out the distinctive rotation of a "Long Track" radar antenna.*" Quoted from David A. Fulgham's article "J-STARS Battles SAMS And Bias at Green Flag," *Aviation Week and Space Technology*, 22 June 1998, 54. JSTARS does not have this capability.

[3] "*AWACS can find [airborne] targets and direct aircraft to intercept and engage them,*" *the official said. "We can do the same by directing aircraft to strike ground movers [such as tanks].*" Quoted from David A. Fulgham's article "New Focus: Battle Command," *Aviation Week and Space Technology*, June 22, 1998. At this time, JSTARS cannot perform this mission without another sensor adding the identification function of the TCT process to confirm the COI is a viable target. Without such cooperation, and if the ROE strictly requires positive identification of the target, then the shooter must conduct visual identification.

Glossary

ABCCC	Airborne Command and Control Center
AC2ISRC	Aerospace Command and Control, Intelligence, Surveillance, Reconnaissance Center
AEF	Air Expeditionary Force
AFDD	Air Force Doctrine Document
AFTTP	Air Force Tactics, Techniques, and Procedures
AOC	Air Operations Center
ARM	Antiradiation Missile
ASCIET	All-Service Combat Identification Evaluation Team
ATO	Air Tasking Order
AWACS	Airborne Warning And Control System (E-3)
BVR	Beyond Visual Range
C2	Command and Control
CAS	Close Air Support
CID	Combat Identification
COA	Course of Action
COI	Contact Of Interest
DBK	Dominant Battlespace Knowledge
DOD	Department of Defense
DSP	Defense Support Program
ELINT	Electronic Intelligence
EO	Electro-optics
FOV	Field Of View
GCI	Ground-Controlled Intercept
GPS	Global Positioning System
HARM	High-speed Antiradiation Missile
HUMINT	Human Intelligence
IADS	Integrated Air Defense System
ID	Identification
IDM	Improved Data Modem

IMINT	Imagery Intelligence
ISR	Intelligence, Surveillance, and Reconnaissance
JASA	Joint Airborne SIGINT Architecture
JDAM	Joint Direct Attack Munitions
JFACC	Joint Force Air Component Commander
JFC	Joint Force Commander
Joint STARS	Joint Surveillance and Tracking Radar System (E-8C)
JSEAD	Joint Suppression of Enemy Air Defenses
MAFB	Maxwell Air Force Base
MLRS	Multiple Launch Rocket System
MOOTW	Military Operations Other Than War
MOUT	Military Operations in Urban Terrain
MPEG	Multi-Platform Emitter Geolocation
MTI	Moving Target Indicator
NAF	Numbered Air Force
NATO	North Atlantic Treaty Organization
OODA	Observe, Orient, Decide, Act
PGM	Precision-Guided Munitions
RJ	Rivet Joint (RC-135V/W)
ROE	Rules Of Engagement
RSTA	Reconnaissance, Surveillance, and Target Acquisition
RTIC	Real-Time Information into the Cockpit
SAM	Surface-to-Air Missile
SEAD	Suppression of Enemy Air Defenses
SIGINT	Signals Intelligence
SPINS	Special Instructions
TA	Target Acquisition
TADIL	Tactical Digital Information Link
TAWS	Theater Airborne Warning System
TCT	Time-Critical Targeting
TIBS	Tactical Information Broadcast Service
TMD	Theater Missile Defense
TPFDD	Time-Phased Force and Deployment Data
TTP	Tactics, Techniques, and Procedures
UAV	Unmanned Air Vehicle
WEZ	Weapons Engagement Zone

The following definitions are provided by Joint Pub 1-02, *DOD Dictionary of Military and Associated Terms*, March 23, 1994. Additional comments are from Maj. James P. Marshall, *Near-Real-Time Intelligence On The Battlefield*, (MAFB, AL: AU Press, Jan 94).

Combat Information. Unevaluated data, gathered by or provided directly to the tactical commander which, due to its highly perishable nature or the criticality of the situation, cannot be processed into tactical intelligence in time to satisfy the user's tactical intelligence requirements. *"Combat Information, or raw intelligence, is more focused to a particular geographic area or target, is sanitized to a usable classification, and is provided without time delays for analysis. The largest drawback of combat information is its dependence on fewer sensors without the opportunity to correlate and analyze the information."* [Maj. James P. Marshall, *Near-Real-Time Intelligence On The Battlefield*, (MAFB, AL: AU Press, Jan 94), p. 1.]

Correlation. 1. In air defense, the determination that an aircraft appearing on a detection or display device, or visually, is the same as that on which information is being received from another source. 2. In intelligence usage, the process which associates and combines data on a single entity or subject from independent observations, in order to improve the reliability or credibility of the information.

Electronic Intelligence. Technical and intelligence information derived from foreign non-communications electromagnetic radiations emanating from other than nuclear detonations or radioactive sources. Also called ELINT.

Fusion. In intelligence usage, the process of examining all sources of intelligence and information to derive a complete assessment of activity. *"The time different between real-time and near-real-time intelligence is a function of this fusion process."* [Ibid., p. 4.]

Information. Facts, data, or instructions in any medium or form. The meaning that a human assigns to data by means of the known conventions used in their representation.

Intelligence. The product resulting from the processing of the collection, processing, integration, analysis, evaluation, and interpretation of available information concerning foreign countries or areas. *"Intelligence comes from multiple sources (all-source), is frequently highly classified, covers large geographic areas, and is used to determine orders of battle and enemy intent."* [Ibid., p. 1.]

Jamming. (or electronic jamming). The deliberate radiation, reradiation, or reflection of electromagnetic energy for the purpose of preventing or reducing an enemy's effective use of the electromagnetic spectrum, and with the intent of degrading or neutralizing the enemy's combat capability.

Near Real Time. Pertaining to the timeliness of data or information which has been delayed by the time required for electronic communication and automatic data processing. This implies that there was no significant delays.

Real Time. Pertaining to the timeliness of data or information which has been delayed only by the time required for electronic communication. This implies that there was no noticeable delays.

Reconnaissance. A mission undertaken to obtain, by visual observation or other detection methods, information about the activities and resources of an enemy or potential, or to secure data concerning the meteorological, hydrographic, or geographic characteristics of a particular area. *"Reconnaissance - produces a 'snapshot' view of the battlefield. While each report may have been 100 percent accurate, it was only accurate for one moment in time--a time in the past."* [Ibid., p. 13.]

Signals Intelligence. A category of intelligence information comprising either individual or in combination all communications intelligence, electronics intelligence, and foreign instrumentation signals intelligence, however transmitted. Also called SIGINT.

Surveillance. The systematic observation of aerospace, surface, or subsurface areas, places, persons, or things, by visual, aural, electronic, photographic, or other means. *"Surveillance reports on what is happening right now. It continuously monitors the situation as it unfolds."* [Ibid., p. 13.] Comparing "reconnaissance" to "surveillance," Maj. Marshall states *"...reconnaissance is used to develop tactical intelligence--that is, it goes through the processing phase of the intelligence cycle before it is available to the decision maker. There is also time to perform a more extensive evaluation of the information and fuse it with information from other sources. Combat information gathered during surveillance is generally from a single source and has not been compared with other sources. Intelligence is evaluated data, while combat information is raw unevaluated data..."* [Ibid., p. 14.]

Target. A geographical area, complex, or installation planned for capture or destruction by military forces

Targeting. 1. The process of selecting targets and matching the appropriate response to them, taking account of operational requirements and capabilities. 2. The analysis of enemy situations relative to the commander's mission, objectives, and capabilities at the commander's disposal, to identify and nominate specific vulnerabilities that, if exploited, will accomplish the commander's purpose through delaying, disrupting, disabling, or destroying enemy forces or resources critical to the enemy.

Target of Opportunity. 1. A target visible to a surface or air sensor or observer, which is within range of available weapons and against which fire has not been scheduled or requested.

Time Sensitive Targets. Those targets requiring immediate response because they pose (or soon will pose) a clear and present danger to friendly forces or are highly lucrative, fleeting targets of opportunity.

From the Air Land Sea Application (ALSA) Center's list of definitions:

Time Critical Target. A lucrative, fleeting, air, land, or sea target of such high priority to friendly forces that the JFC/component commander designates it as requiring immediate response. TCTs pose, or will pose, an imminent threat to friendly forces or present an exceptional operational or tactical opportunity.

Author's definitions:

Active Sensor. Sensor that emits energy, and obtains information from the energy reflected off the target.

MOOSE. The Method Of Optimized Sensors/shooters Employment, or the critical path, formed by the constellation of sensors and shooters which provide all functions of the time-critical
targeting process in the shortest amount of time.

Passive Sensor. Sensor that obtains information by collecting the target's own emissions.

Targeting Constellation. A combination of sensors and shooters which provides all five targeting functions of time-critical targeting. The MOOSE identifies the single, optimized targeting constellation able to engage a particular target in the shortest amount of time.

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Precision Factors of the TCT Model

Two factors determine the precision required from the location and identification functions of the TCT model. These factors are the type of weapons employed against the target and the theater ROE (which stipulate what force can be applied and how it can be applied). It is critical the theater JFACC be familiar with these precision factors, since the JFACC may have the ability to change them and, thus, alter the precision required in the TCT model. Adjusting precision gives the JFACC a wider range of employment options.

a. Weapon Type (Figure 7).

Once sensors have adequately identified the target, and C2 has committed the shooter to attack the target, the shooter must locate it and engage it.[14] It is the weapon the shooter uses to engage the target that drives target location precision, and thus limits the systems that may provide target location information. For example, a passive SIGINT sensor can locate a track with enough precision to employ a broad area weapon such as a HARM or Army multiple launch rocket system. This precision is not sufficient for GPS-guided weapons. Only an active sensor (a radar) or a passive imaging sensor can currently obtain this level of precision. In other cases, location may not be important at all. Jamming platforms do not require an extremely precise position of their target to successfully engage the target. The weapon drives the location precision required, and therefore the necessary sensors to determine that location. A JFACC must realize some of his sensors can not provide the location precision required by some precision weapons. Long-term planners must also realize that as the precision of weapons increase with technology, it must be matched by advances in those systems that locate targets.